Cogeneration Sourcebook

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PREFACE

This Sourcebook is intended to help facilitate the implementation of private and public sector cogeneration projects in the Province of Ontario. It provides much useful information for the potential cogenerator, such as how to assess the feasibility of cogeneration and where to obtain assistance for planning and implementing cogeneration projects. It describes the fundamentals of cogeneration and the characteristics of various commercially-available technologies. It also describes various financing options, the approvals process, and requirements for connection with the electricity grid system. Additional information on cogeneration, related government support programs, financing, and approvals, can be obtained by contacting :

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INTRODUCTION

Background

Industry has been involved in the cogeneration of electrical power and heat since the turn of the century. At that time, bulk power distribution systems were at an early stage of development. Independent generation of electricity was considered to be more reliable and less expensive than off-site power generated by utilities. Though cogeneration was common, most on-site generation came from small hydro installations.

Subsequently, however, there was a significant overall decline in independent power generation, including cogeneration. Utility-generated power became more reliable and cheaper to buy. Cogeneration tended to be more attractive in remote areas, where connection to the electricity grid was difficult, or where an industry had access to cheap waste fuels.

But in recent years there has been a resurgence of interest in cogeneration as a cost-effective, reliable, efficient, and environmentally sound alternative or supplement to utility-generated power. In the United States, for example, the high level of cogeneration activity is the result of special legislation enacted to encourage the conservation of fossil fuels and to improve energy-use efficiencies. American cogenerators now have about as much total generation capacity as Ontario Hydro.

It has been estimated that well over 1000 MW of cogenerated power could be feasibly developed in Ontario by the year 2000. Industries with high-energy needs have led the way in cogeneration, but institutions, municipalities, and owners of large residential complexes have also shown strong interest. All of them have recognized that cogeneration offers the potential of substantial energy cost savings or increased revenues.

In the Province of Ontario, privately generated power can be sold to Ontario Hydro or a local utility. The generation of electricity from equipment which is neither owned nor operated by an electrical utility, but which is connected to the electricity grid system, is known as 'parallel generation.'

Cogeneration Defined

Virtually all industrial, institutional, and commercial facilities utilize thermal and electrical energy. To meet their thermal demand, most facilities produce heat on-site in the form of steam or hot water from a supplied fuel source. Electricity, on the other hand, is usually purchased from an off-site electrical utility. Through **'cogeneration'**, the production of both heat and electricity is combined into one on-site process. Very simply, cogeneration is defined as the simultaneous production of electrical and thermal energy from a single fuel source. Typical fuel sources for cogeneration include natural gas, diesel oil, and biogas (such as methane from digesters and municipal landfills).

Types of Cogeneration Systems

There are various types of cogeneration systems. One type utilizes a gas engine or gas turbine driven generator to produce electricity. A portion of the heat in the cooling water and hot exhaust from the engine or gas turbine is recovered to produce steam or hot water for industrial process and for space heating. Steam can also be used to drive a small turbine to produce more electricity, thereby increasing the electrical and overall conversion efficiency of the system.

Another type of cogeneration system uses a high-pressure steam boiler and a steam turbine driven generator. In this configuration, heat is available in the form of either low or high-pressure steam for use in an industrial process or for space heating purposes.

Definition of Efficiencies

Overall fuel energy conversion efficiency is the sum of the thermal recovery and electrical conversion efficiencies of a cogeneration system. This ranges between 65 to 80 per cent for typical cogeneration systems. Thermal recovery efficiency refers to the proportion of total fuel energy recovered as heat. This range is typically between 40 to 50 per cent. Electrical conversion efficiency is the proportion of total fuel energy converted into electrical energy. It ranges between 15 and 34 per cent.

The Benefits

The major benefit of cogeneration is that it offers the potential for achieving substantial energy cost savings. This is primarily because cogeneration is a very efficient means of producing electrical and thermal energy. By utilizing the heat which is normally rejected by a power generating system to produce steam for use in an industrial process or as hot water for space heating, overall energy conversion efficiencies of more than 80 per cent are typical for many existing industrial cogeneration systems. This compares to an overall conversion efficiency of only 30-40 per cent for conventional power generating systems which reject heat directly into the environment.

On an equivalent energy unit basis, electricity is more expensive than the fuel used to produce it. Thus, combined with efficient heat recovery and utilization, more energy value can be obtained from each dollar spent on a relatively inexpensive fuel to cogenerate electricity and heat than if it had been spent on the separate purchase of electricity and heating fuel. The difference between the cost to cogenerate electricty and heat and what it would cost to purchase an equivalent unit amount of utility-generated electricity and heating fuel provides 'bottom line' savings for cogenerators. In the case where electrical power is sold back to a utility, the cogeneration plant produces revenue.

In summary, cogeneration can provide many potential benefits such as energy cost savings, improved reliability of electrical energy supply in the form of standby power, and enhanced process flexibility. Potential revenues can also be realized from the sale of electricity to utilities or from surplus steam and hot water sold to neighbouring users.

The greatest potential for cogeneration applications exist in industrial facilities with continuous thermal and electrical power requirements, such as pulp and paper, textile, and steel mills, and food processing and chemical plants. Large commercial and multi-unit residential buildings may also derive substantial benefits from cogeneration.

This small 15 kW cogeneration package, fuelled by biogas generated on-site, provides additional electricity for a farm facility as well as hot water used in the anaerobic digestion process.

COGENERATION TECHNICAL FUNDAMENTALS

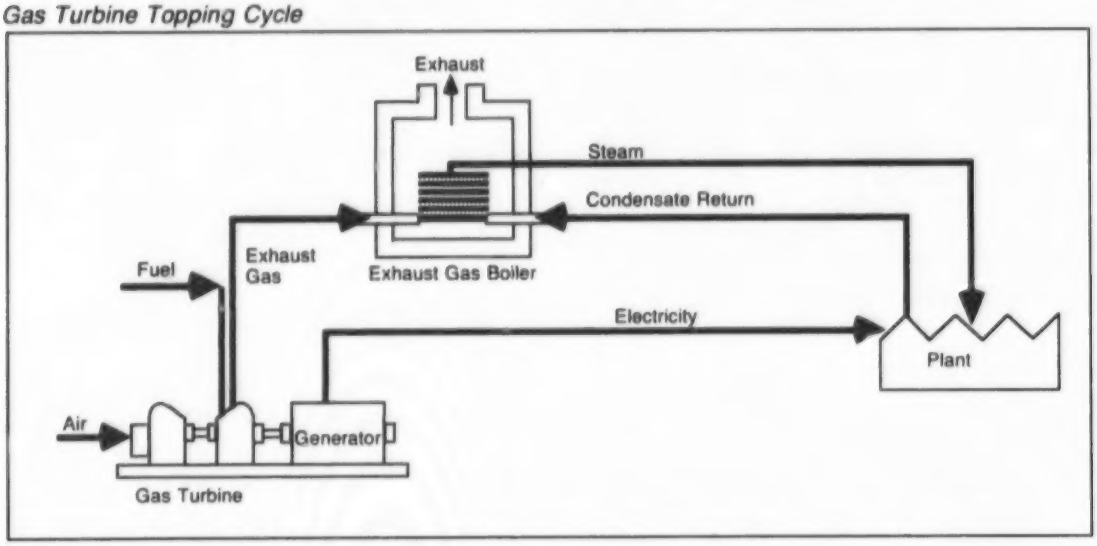
Operating Cycles

Cogeneration systems come in two basic configurations or "**operating cycles,**" depending on whether mechanical/electrical power is produced before or after heat is extracted for thermal application.

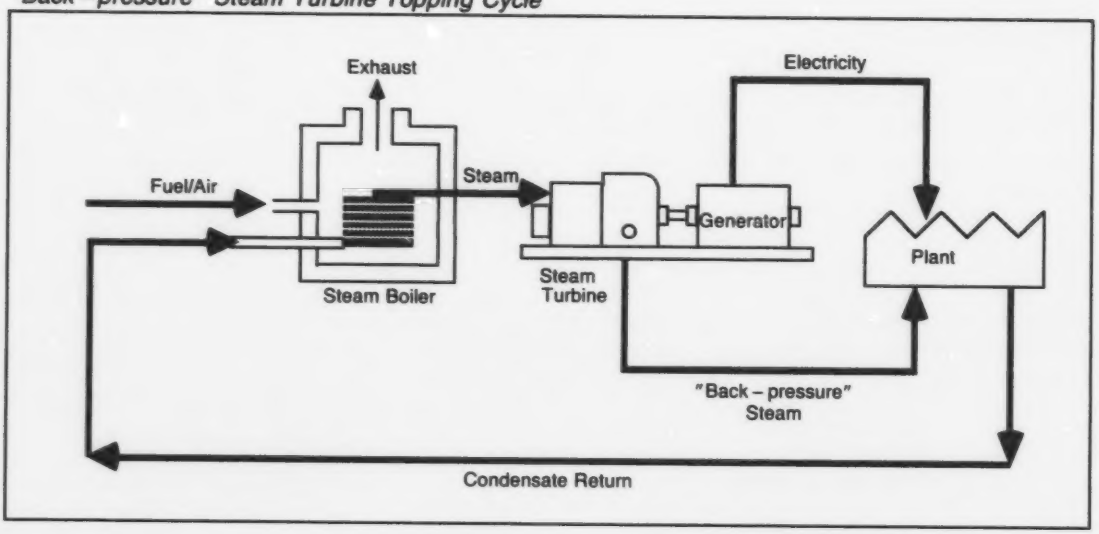
The system in which electrical power is produced first, followed by the extraction of heat, is known as a "**topping cycle.**" This is the most common type of cogeneration system. Prime movers typically used in topping cycle systems include reciprocating engines (gas and diesel) and gas turbines. After electricity is generated, the combustion exhaust gas is sent to a heat-recovery boiler where hot water or steam is produced. In the case of engines, heat is also recovered from the jacket water cooling circuit, and this represents the dominant contribution.

"**Bottoming cycle**" systems reverse this process. High-temperature steam or hot water is first produced in a boiler primarily for thermal application. The residual steam or hot water is then used to drive a steam-turbine to generate electricity. While a bottoming cycle system is highly efficient because no additional fuels are required to produce electricity, its application is limited to situations with relatively high-temperature thermal requirements. Only steam turbines and steam engines, which operate on the Rankine cycle, are used in bottoming cycle systems.

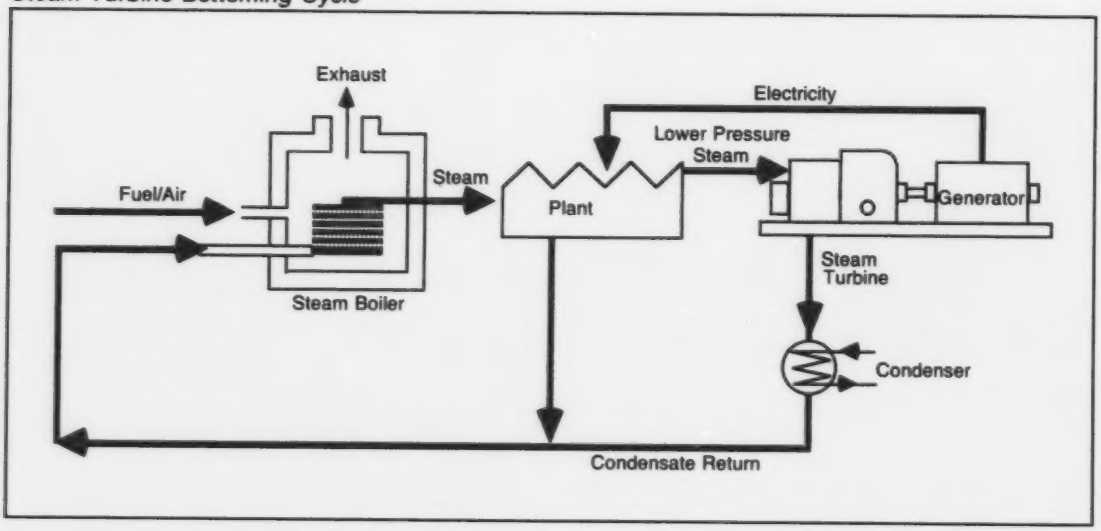
Gas Turbine Topping Cycle



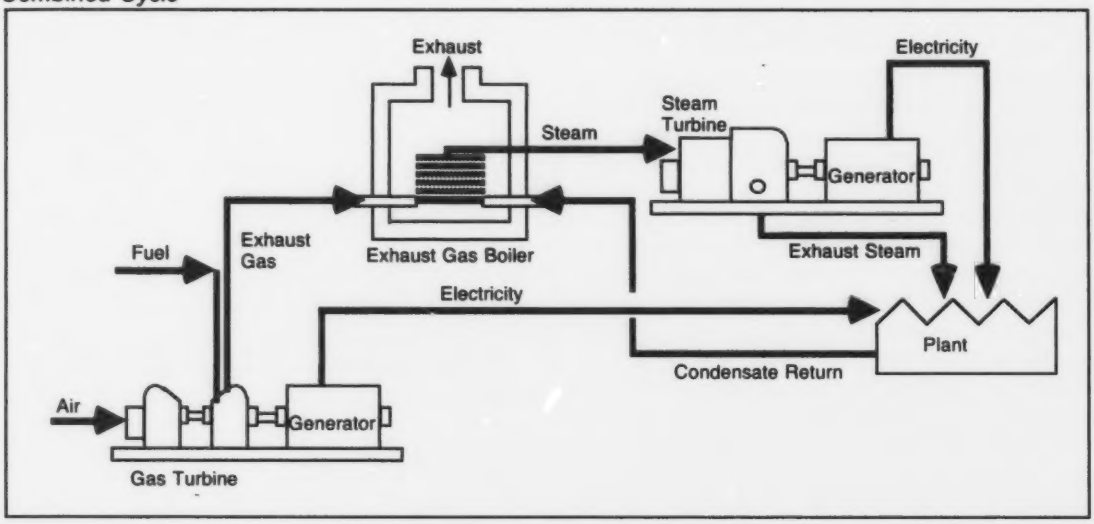
"Back – pressure" Steam Turbine Topping Cycle



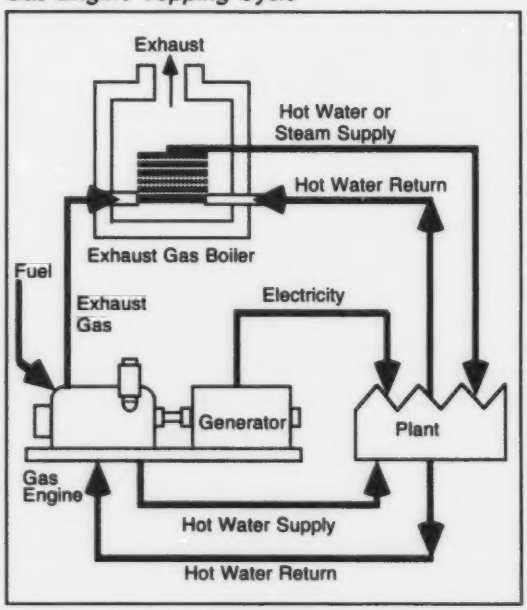
Steam Turbine Bottoming Cycle



Combined Cycle



Gas Engine Topping Cycle



Prime Movers

The heart of any cogeneration system is the prime mover which produces mechanical energy to drive an electric generator or alternative device (pump, compressor, etc.) together with thermal energy for space heating, process, and so forth. Most prime movers have an electrical conversion efficiency in the order of 30 per cent, but the overall energy conversion efficiency can be enhanced to roughly 80 per cent by utilizing their available heat in a cogeneration setting.

When a **reciprocating engine** is utilized as the prime mover, the engine provides heat from its jacket cooling water, exhaust gases, and even its lubricating oil. These engines are generally fuelled by natural gas, propane, gasoline, or diesel oil, but may also use biogas, syngas, and hydrogen. Efficient, compact, and easy to transport and install, they are ideally suited to smaller cogeneration applications that require either hot water for space heating or low-pressure process steam, i.e., below 105 kPa (15 psig).

Gas turbines are generally suited to higher power applications, and are relatively compact, reliable, and easy to install. In a gas turbine, the combustion products from compressed air and fuel are expanded through a turbine to produce the mechanical energy for driving a generator, then pass through a heat recovery boiler at 450 to 550°C (840 to 1000°F) to generate steam — typically at higher pressure for industrial process heating. Alternatively, high pressure steam can be used to feed a steam turbine which is used as an additional source of mechanical or electrical power. Steam generation can be enhanced by adding supplementary fuel to the oxygen rich exhaust gas before the boiler. This "combined cycle", as it is called, is a highly efficient method of producing mechanical/electrical energy, however, it is generally feasible only in larger industrial applications.

In a **steam turbine**, the energy to drive a generator is derived from expanding steam. Larger steam turbines above 10 MW have a good operating efficiency, and their associated boilers can be fired by a wide variety of fuels such as natural gas, fuel oil, or coal, and also solid wastes such as refuse and wood. When an "extraction" steam turbine is used, a portion of the steam flow can be removed at a lower pressure from an intermediate point in the steam expansion process. If a "back pressure" steam turbine is used, the entire steam flow, at lower pressure, can be utilized after it passes through the last stage of expansion.

More specialized cogeneration systems can be built around organic Rankine cycle engines, Stirling engines, fluidized bed combustion systems, solar power systems, and fuel cells. These technologies, though proven in other applications, are in varying stages of development for current use in cogeneration.

Electric Generators

There are two basic types of electric generators available on the market, induction and synchronous. Of the two, the **induction unit** is simpler and slightly less expensive.

Because an induction generator draws its magnetizing current from the local electrical utility, it does not require special control devices for synchronization with the utility. A possible draw back is that the inductive nature of the magnetizing current can lead to a poor power factor at part-loads. This problem can be corrected by installing a capacitor bank if required.

As long as there is a continuous external power supply, providing excitation, the induction generator continues to produce electricity. Should there be any interruption in that supply, the generator stops producing electricity. Thus, it is not suitable for standby power applications.

A **synchronous generator**, on the other hand, produces its own magnetizing current, and is therefore suited to standby power generation. However, the requirements for connecting a synchronous generator to an electrical utility system are somewhat more elaborate. For example, a synchronous generator will require the installation of special synchronizing devices to match its electrical output characteristics to that of an electrical utility.

Thermal Applications

Thermal energy produced by a cogeneration system may be used for a number of purposes including industrial processes, space heating, water heating, dehumidification and air conditioning. The last one is accomplished through the use of commercially available absorption chillers requiring either low pressure steam or hot water.

In a reciprocating engine, approximately two-thirds of the available waste heat comes from the cooling jacket water. This heat is available in the form of either hot water at 80-120°C (180-220°F) or as low-pressure steam at approximately 105 kPa (15 psig). The available heat in the engine exhaust can be recovered by passing it through an exhaust gas boiler. Note that the inlet temperature of the exhaust gas can be as high as 650°C (1200°F), but its outlet temperature should not drop below 150°C (300°F) to avoid mildly corrosive acids in the gas from condensing on the inside surfaces of the boiler.

The available heat which can be recovered from a gas turbine comes from its exhaust gas stream. Discharged from the turbine at approximately 500°C (930°F), the hot gas passes through a heat recovery boiler where high-pressure steam is produced. Again, the amount of heat recovered should not bring the temperature of the exhaust gas below 150°C (300°F) in order to avoid damage to the boiler from corrosive acid condensate.

In the case of a steam turbine, heat is already available in the form of extraction or back-pressure steam which can be used directly to suit the specific thermal requirements of an industrial process.

System Efficiencies

The efficiency of a cogeneration system can be looked at from two perspectives: its **electrical conversion efficiency** and its **thermal recovery** efficiency. The sum of the two is referred to as the **overall system efficiency**.

The **heat rate** is an indirect parameter used to develop the electrical conversion efficiency of a power generating system. The lower the heat rate, the more efficient the system. It is defined as the fuel input heat (conventionally expressed in British Thermal Units per hour) required to produce the electrical output power (kW), namely:

$$\text{Heat Rate} = \frac{\text{Fuel Input Energy (BTU/hr)}}{\text{Electrical Output Power (kW)}} \quad \text{BTU/kWh}$$

The electrical conversion efficiency of an electrical power generation system is expressed as follows:

$$\text{Electrical Conversion Efficiency(\%)} = \frac{\text{Electrical Output (kW)} \times 3412\ \text{BTU/kWh}}{\text{Fuel Input Energy (BTU/hr)}} \times 100$$

The thermal recovery efficiency of the heat generation system is defined as follows:

$$\text{Thermal Recovery Efficiency(\%)} = \frac{\text{Thermal Energy Recovered (BTU/hr)}}{\text{Fuel Input Energy (BTU/hr)}} \times 100$$

The overall cogeneration system efficiency is the sum of the electrical and thermal efficiencies, namely:

$$\text{Overall System Efficiency(\%)} = \text{Electrical Conversion Efficiency(\%)} + \text{Thermal Recovery Efficiency(\%)}$$

CHARACTERISTICS OF PRIME MOVERS

Technology	Nominal Power Range (Electrical)	Advantages	Disadvantages
Reciprocating Engines (Gas and Diesel)	10 to 3000 kW	• Reliable • Higher electrical conversion efficiency particularly at part-load • Comes in small sizes • Lower capital cost	• Lower level waste heat temperature • Higher maintenance than gas-turbine • can be noisy (lower pitch)
Gas-Turbines	1000 to 80,000 kW	• Reliable • Lower maintenance than reciprocating engines • Compact, lightweight, easy to set up • Heat recovery from waste-heat boiler is good (steady and high flow)	• Requires gaseous fuel compression up to 1400 kPa (250 psig) • Lower part-load efficiency than reciprocating • Can be noisy (higher pitch)
Steam-Turbines	1000 to 100,000 kW	• Long life • Associated boiler burner can use variety of fuels • Technology well established and understood	• Lower electrical conversion efficiency in smaller sizes • Uneconomical in smaller sizes • Higher labour burden (requires licensed stationary engineers in attendance) • Accompanying boiler plant is awkward.

TYPICAL COGENERATION PERFORMANCE PARAMETERS

Prime Mover in Cogen. Package	Nominal Range (Electrical)	Electrical Generation Heat Rate (Btu/kWh)	Efficiencies %		
			Electrical Conversion	Thermal Recovery	Overall Cogeneration
Smaller Reciprocating Gas Engines	10-500 kW	25,000-10,500	20-32	50	74-82
Larger Reciprocating Gas Engines	500-3000 kW	13,000-9,500	26-36	50	76-86
Diesel Engines	10-3000 kW	15,000-11,000	23-38	50	73-88
Smaller Gas Turbines	800-10,000 kW	14,000-11,000	24-31	50	74-81
Larger Gas Turbines	10-20 MW	13,000-11,000	26-31	50	78-81
Steam Turbines	10-100 MW	20,000-10,000	17-34	-	-

NOTE: Adapted from *Cogeneration Handbook* California Energy Commission, 1982.

Sizing a Cogeneration System

The "size" of a cogeneration system is its rated capacity of electrical power production. A cogeneration system should be sized appropriately so that it is matched to the thermal and electrical energy requirements of a building facility. This will help to maximize the yearly operating time during which efficient utilization of both electricity and the heat recovered can be achieved simultaneously.

To achieve an appropriate energy matching, an accurate and comprehensive energy audit of a building facility should be completed in order to determine its thermal and electrical energy "load profile" (see **Project Feasibility**). This includes the determination of daily, seasonal, and peak variations in loads; continuous minimum load (base load); and expected future changes in loads.

Operational Strategies

When operating a cogeneration system, the following two objectives should be kept in mind:

- The system should be operated so that the maximum amount of recoverable heat is utilized.
- The prime mover should be operated as close as possible to its full rated capacity thereby obtaining highest revenue and the highest electrical conversion efficiencies.

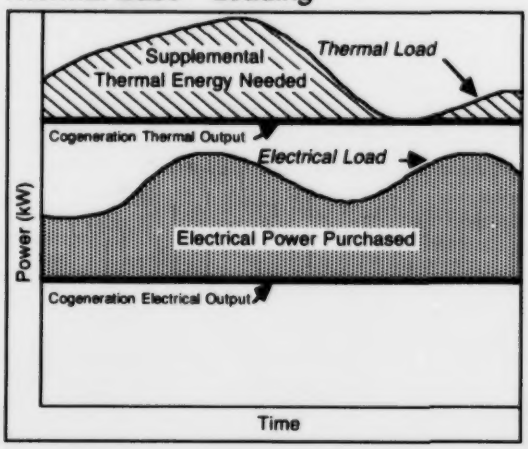
The most straightforward approach to achieving the previous objectives is called **base-loading**. The system can be designed to be either thermally or electrically base-loaded.

If it is thermally base-loaded, the cogeneration system is sized by the level of thermal output required to match the minimal or "base" yearly heat demand of the plant, while its electrical output is used to supplement the electrical demand. Conversely, an electrically base-loaded system has its electrical output matched to the base electrical demand, while the thermal output is used to supplement the thermal demand. In either case, the amount of thermal or electrical energy required above the amount produced is supplied by other sources. The main advantage of this mode of operation is that the prime mover operates at full rated capacity.

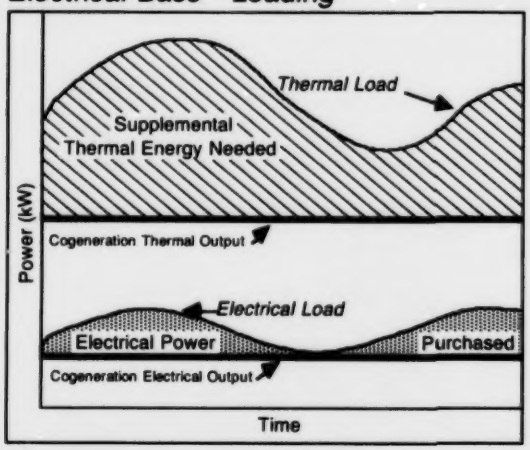
In a **load-following** approach, the power and heat outputs of a cogeneration system follow fluctuations in either electrical or thermal load. In an electrical load-following approach, the electrical output of the cogeneration system is controlled to match the plant electrical power load. The resulting thermal output is used to supplement the plant thermal load. Conversely, in a thermal load-following approach, the thermal output of the cogeneration system is controlled to match the thermal demand of the plant, while the electrical output is used to supplement the plant electrical load.

"Import/Export" electrical load levelling is another approach which may add flexibility to the operation of a system. Surplus electrical power can be exported from the cogeneration system during excess generation periods, while supplemental power is imported to the system from the utility. The output of the system remains constant since the load is "levelled".

Thermal Base – Loading

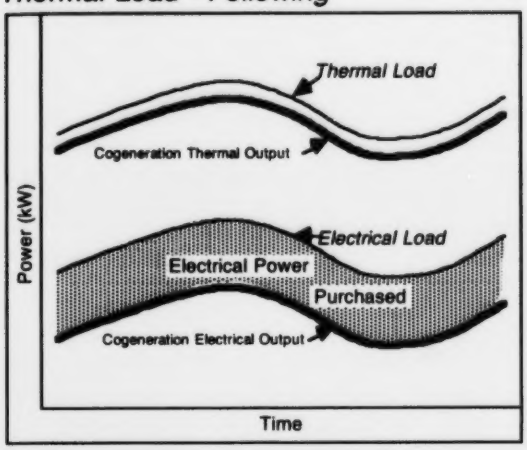


Electrical Base – Loading

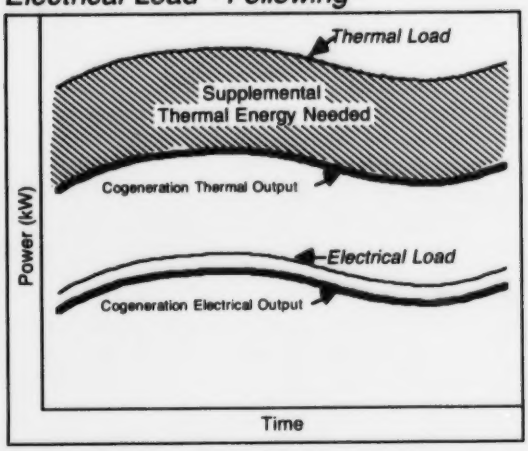


However, a cogenerator offering a steady and reliable (rather than intermittent) supply of export power to a utility will likely be eligible for higher purchasing rates.

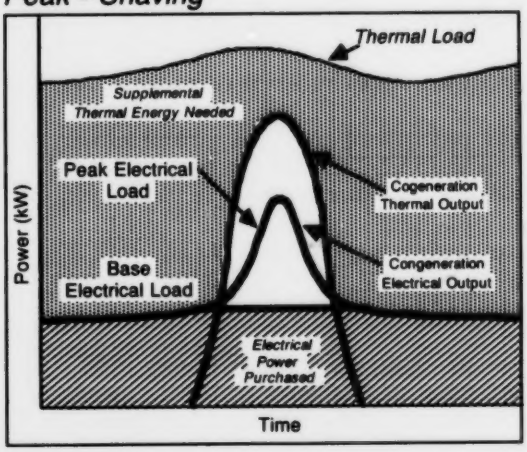
Thermal Load – Following



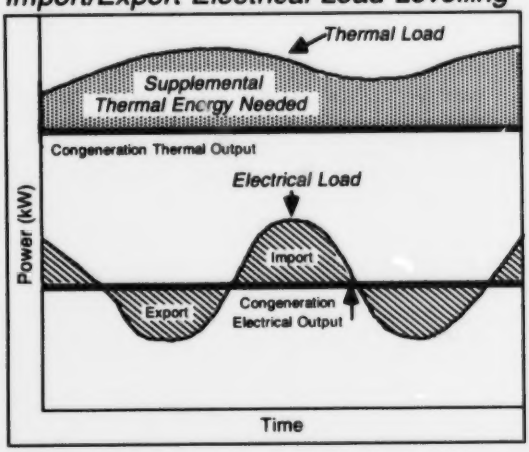
Electrical Load – Following



Peak – Shaving



Import/Export Electrical Load Levelling



In certain circumstances it may be viable to operate a cogeneration system in either a daily or seasonal **peak-shaving** mode. For plants with large peaking electrical loads on a daily basis, substantial demand savings can be achieved if the cogeneration system is controlled to supply only the peak portion of the plant's daily electrical load. However, one limitation of this approach is that the thermal output of the system is available for only short periods during the day. Seasonal peak-shaving, in which the cogeneration system is used to supply the peak portion of the annual electrical demand, is more feasible than daily peak-shaving since its thermal output is more constant and reliable.

Electrical Utility Connection

Although they can be operated in isolation from an external electrical utility, most cogeneration systems require connection with a utility-operated distribution system. This gives the cogenerator the flexibility to purchase supplemental electrical power when required, as well as the opportunity of selling surplus generated power back to the utility when desired.

A cogenerator connected to the utility grid is known as a "parallel generator."

The details of the parallel connection will vary between induction and synchronous generator installations. This should be engineered by an authority familiar with the requirements of both types of generators as well as the requirements of the local electrical utility.

The broad design objective of the connection is to ensure the utility and the cogenerator can safely operate in parallel while avoiding mutual damage. The design must include protection for the supply authority from faults originating from the cogenerator's system and vice versa. Proper isolating and protection devices must be used as required. Synchronizing equipment must be installed where synchronous generators are used. Circuit breakers, switches and fuses used must have ratings that meet utility standards.

Ontario Hydro and the local utility should be contacted to obtain the latest guidelines for electrical connection as well as review of the final design prior to construction (For more details see section on Applicable Regulations and Approvals).

Packaged Cogeneration Systems

A number of suppliers offer standardized or packaged cogeneration systems where the planning and assembly of cogeneration components are done in the shop. The most common prime mover in a packaged system is a small spark-ignition gas engine of relatively high speed — available in sizes ranging from 10 to 500 kW.

To select the optimum cogeneration package careful consideration must be given to the space limitations and the electrical and thermal requirements of the cogeneration's facility. The supplier should have good understanding of the cogenerator's needs prior to the final selection of the package.

The use of packaged systems provides a number of potential advantages over site-assembled cogeneration systems:

- The total capital and installation costs tend to be slightly lower, particularly in applications of 100 kW or less;
- Installation is comparatively easier and faster;
- Packaged systems are inspected and test-run in the shop where faults can be more easily identified and corrected prior to installation;
- A single firm is responsible for ensuring the performance of the cogeneration system meets project specifications.
- In some cases, the same firm can offer a fixed-price maintenance contract, thereby minimizing both the owner's involvement in maintenance and the uncertainty of repair costs;
- Packaged systems are available with a wide variety of heat recovery options to provide either hot water, steam, or chilled water.
- Packaged cogeneration systems are feasible for most industrial and a wide range of commercial and institutional applications.

PROJECT FEASIBILITY

This section identifies the main information required for undertaking a comprehensive technical and economic feasibility analysis of a cogeneration project. (For regulatory and financing considerations, see the sections on Applicable Regulations and Approvals and Ownership and Financing Options respectively.)

Consultants experienced in the engineering and financial appraisals of cogeneration systems can be retained to provide a comprehensive project feasibility analysis.

Basic Steps

In undertaking a feasibility analysis of a cogeneration project, the merits of cogeneration are usually compared to the alternative of conventional production of heat and purchase of electricity.

Determining the overall feasibility of a cogeneration project is generally site-specific; however, there are a number of basic steps which should be followed:

- **Step One**—Preliminary project feasibility, answers some basic questions about whether cogeneration is broadly appropriate for a particular situation;
- **Step Two**—Technical feasibility, addresses issues in more detail related to the size, type, operation, and suitability of a cogeneration system for a particular facility;
- **Step Three**—Economic feasibility, considers capital cost plus operation and maintenance costs, and how they can be offset by energy cost savings and other potential revenues in order to determine the return on investment;
- **Step Four**—Regulatory acceptability, includes consideration of all regulatory approvals required for the project;
- **Step Five**—Financial feasibility, addresses the options for securing financing for the project.

Preliminary Project Feasibility

Before a decision to cogenerate heat and electrical power is made, it is essential that the following questions be answered about the suitability of a facility for cogeneration:

- Are the electrical and thermal load requirements suitable for cogeneration? The average loads for the plant should be determined as well as nature of the thermal load-characterized in terms of temperature, pressure, and load-factor should be considered.
- Is there a reasonably continuous demand for electricity and heat? Daily or seasonal variability in load will tend to reduce the efficiency gains that can be achieved through cogeneration. Optimal efficiency is achieved when electrical power and heat demands are uniform and occur simultaneously over a long period.
- What are the purchased costs of fuel and electricity in the region? A relatively inexpensive fuel compared to a high electrical purchase rate makes cogeneration a favourable alternative.
- Are there any modifications to buildings, services, or processes which must be made in order to integrate the cogeneration system with plant? The costs of these modifications, which are sometimes neglected, may have a significant impact on the feasibility of the project particularly for smaller projects.

- What, if any, fuel restrictions exist? When selecting a cogeneration system, the short and long-term availability of fuels as well as restrictions on their use should be considered. When natural gas is used, the available pressure at the building interface should also be considered —particularly for a turbo-charged engine which requires at least 170 kPa (25 psig) supply pressure. A prime mover such as the gas turbine requires gas pressure in the order of 1700 kPa (250 psig) which often necessitates a separate gas compressor.

Technical Feasibility

Once it has been established that some potential exists for cogeneration, a more in-depth feasibility analysis should be undertaken. An energy demand profile, is developed together with performance parameters of alternative cogeneration systems, plant integration requirements, fuel source security, and other requirements for operation and maintenance.

i) Energy Demand Profile

A comprehensive energy demand profile is produced through an "energy audit." The database to be compiled for an energy demand profile should include at least the following information:

- Required characteristics and mass flow for process heat streams; e.g. hot water vs steam, low vs high pressure steam;
- Annual fuel consumption, obtained from plant records. This is particularly useful in determining the thermal load profile;
- Annual steam and hot water consumption, with daily and seasonal variations and future load projections;
- Annual electrical energy consumption and power demand patterns, with daily and seasonal variations and future load projections.

ii) Cogeneration System Performance Parameters

Using the energy demand profile, an appropriate cogeneration system can be selected and sized according to how well its electric and thermal outputs suit the pattern of the power and thermal requirements of the facility. To do this, the following basic performance data for different cogeneration systems should be obtained:

- Electrical power rating of the prime mover/generator package;
- Heat-recovery capabilities of the cogeneration system, and the nature of its thermal output (hot water, low or high-pressure steam);
- Fuel consumption of the cogeneration system,
- Service life and maintenance requirements, including a detailed maintenance program throughout the life of the project.

iii) Plant Integration

The integration of a cogeneration system into a building's existing electrical/mechanical systems, or an industrial plant's process, requires modifications to the existing systems at various "interface points." Architectural and structural modifications to the building itself may also be needed.

At this stage, the types of auxiliary equipment required for plant integration should be identified. As well, the space requirements for the installation of a cogeneration system should be determined and compared to the area of space available in closest proximity to the interface points.

iv) **Fuel Source Security**
Implicit in the selection of a cogeneration technology is the choice of a specific fuel. In the selection of fuel alternatives, careful consideration should be given to the short and long-term availability of various fuels.

It is also important that, at this stage, some thought be given to the type of fuel supply contract (see Energy Contracts), since this may later influence the economic feasibility of the project. For instance, long-term gas supply contracts can be negotiated under certain circumstances. Such contracts help to provide a greater measure of protection against future fluctuations in fuel cost and availability.

Economic Feasibility

Once a technically feasible cogeneration system has been identified, the next step is to assess its economic feasibility. The ultimate goal of this analysis is to determine whether cogenerating electricity and heat is less costly than purchasing electrical power and producing heat separately. In order to make this assessment, the following aspects should be considered:

- The capital cost associated with purchasing and installing the cogeneration system;
- The costs for fuel, maintenance and other operational aspects, and how these vary during the service life of the cogeneration system;
- Purchase rates of electricity from the local utility in terms of both demand and energy;
- The utility's purchase rate of surplus electricity from a "parallel generation" in terms of both energy and capacity factor;
- The net savings accrued from the electricity and heat produced by the cogeneration system in comparison to other options.

Capital Costs

Estimating the total capital costs for a cogeneration system may seem straightforward; however, there are a number of important cost considerations in addition to the purchase and installation of the basic equipment which should not be overlooked. Some of these include:

- Plant integration costs for such items as piping, controls, and structural or architectural modifications to the building;
- Costs of interconnection with the utility-owned electricity system,
- Costs of auxiliary equipment such as noise suppression systems, waste heat radiators, air pollution control equipment, air compressors; and space cooling fans.

Operation and Maintenance Costs

Some of the key factors which bear upon these costs include:

- Staff requirement relative to type of prime mover used;

  For example, a cogeneration system comprising a large steam turbine and high-pressure steam boiler requires a 24-hour daily commitment of qualified operating staff. However, a smaller engine installation does not require any specially skilled operators.

- Characteristics of the prime mover;

  For example, in the case of an engine, maintenance cost increases with higher engine speed, and a naturally-aspirated engine is less expensive to maintain than a turbo-charged one.

- Maintenance arrangements and personnel training to manage and operate a cogeneration system;

  For a smaller cogeneration system, the maintenance can often be economically performed by in-house staff.

  For larger cogeneration systems, maintenance costs may be reduced through contracted arrangements with the equipment supplier or equivalent group.

- The availability of spare parts and technical expertise of an equipment supplier;

  This affects the duration and cost of both scheduled and unscheduled downtime.

Economic Measures

A number of alternative methods can be used to evaluate the economic feasibility of a cogeneration investment. Among the most commonly used are various types of discounted cash flow methods and simple payback period.

The **payback period** provides a simple first order screening of economic feasibility. The payback period is the length of time required for the cumulative net savings generated by an investment to equal the initial installed capital cost. It is easily calculated by dividing the initial investment by the annual net savings.

Simple payback period is easy to apply and understand. Its basic drawback, however, is that it does not consider the overall size of the investment over the life of the project or the time value of money. The **discounted cash flow** methods provide a better approach for evaluating the economic feasibility, particularly when comparing two alternative approaches, because they analyze revenue or cash flows over the full life of the project and account for the time value of money.

The discounted cash flow methodologies include; **net present value, internal rate of return,** and **benefit cost ratio.** All of these approaches are based on the concept of the time value of money, namely that a dollar received today is worth more than a dollar received in the future. (e.g. a dollar received today can be invested, earn interest and yield more than a dollar in the future).

Under all these approaches, a discount factor (to account for the time value of money) is applied to cash flows received in the future to determine an equivalent present value. The impact of this approach is illustrated in the cash flow analysis figure. The **net present value** (NPV) represents a single current lump of money that is equivalent to the summation of the cash flow associated with an investment opportunity. It is calculated as follows:

- Select a discount rate equivalent to the minimum rate of return acceptable to project investors.

- Apply discount factors, based on the selected rate, to the cash flows associated with the investment to determine the present value of these items.

- Sum the present valued cash flows, netting cash outflows (investments) with cash inflows (returns), to yield the net present value of the investment.

If the NPV is positive then the investment provides an acceptable return. If it is negative, the proposed project does not generate the return required by the investors. When comparing alternative approaches, the approach that yields the largest positive net value should be selected.

The **Internal Rate of Return (IRR)** provides a measure of the overall return on the investment. It is, by definition, the discount rate that makes the net present value equal to zero. As illustrated, the IRR can be calculated using a trial and error approach by determining the net present value under a range of discount rates. (Note: As successively higher discount rates are applied, the NPV will decrease and eventually become negative. The IRR is therefore the unique discount rate that yields a zero NPV.

The **benefit cost ratio** is simply the ratio of the present value of the benefits (eg. cash inflows) over the present value of the costs (eg. cash outflows). Once an appropriate discount rate has been set, a benefit cost ratio greater than one implies a favourable investment opportunity.

Cash Flow Analysis

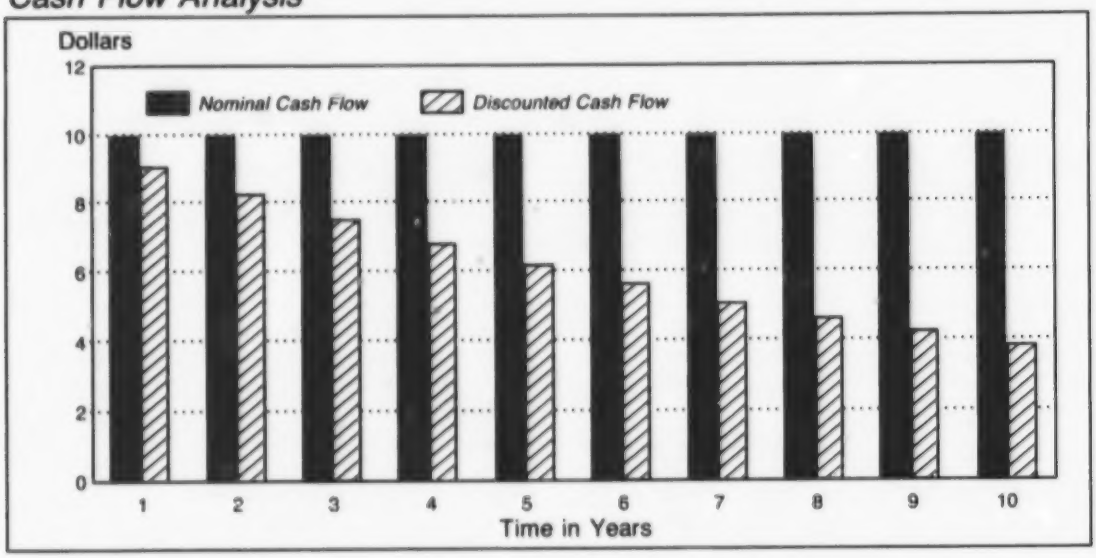
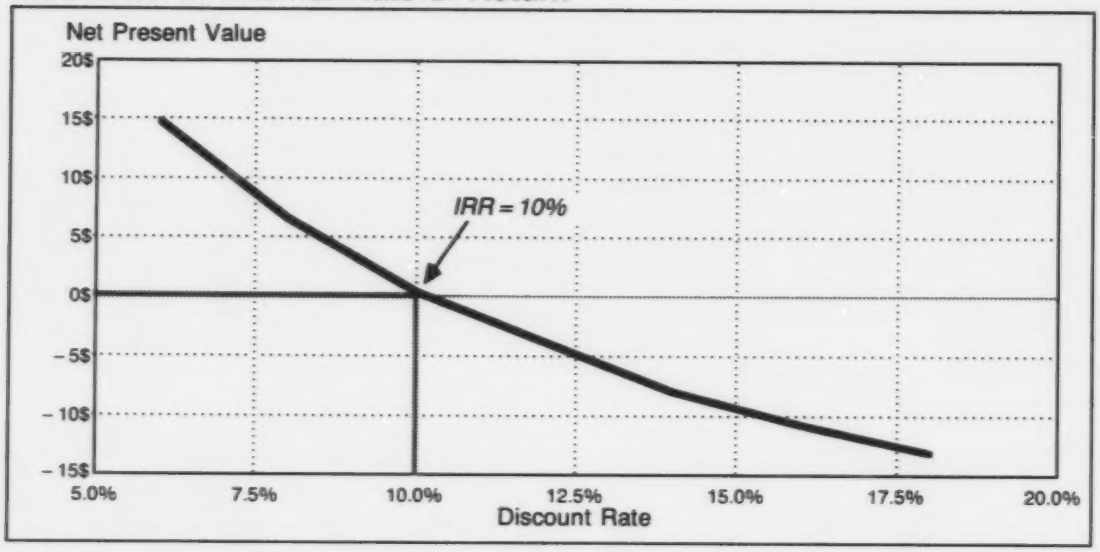


Illustration of Internal Rate of Return



Regardless of the measure employed, there are a number of potential situations where an investment in cogeneration may be particularly attractive. Some examples include:

- Where a capital investment is already required to replace or significantly modify an existing central heating plant;
- Where a new central heating plant is required; and
- Where stand-by power in the form of an engine generator set is required.

In these situations the economies associated with the cogeneration investment are significantly improved if only the additional capital costs for the cogeneration system are considered.

APPLICABLE REGULATIONS AND APPROVALS

Electrical Connection, Inspection and Approvals

The design, construction, and installation of all cogeneration equipment located on cogenerator-owned property is subject to inspection and approval by the local electrical utility.

Typically, any alterations to an electrical utility's distribution grid as a result of the connection of a cogeneration system will be designed and implemented by the utility at the expense of the cogenerator (or parallel generator). The utility, however, will be financially responsible for purchasing, installing, and maintaining all billing and purchase metering equipment.

The local electrical utility should be notified in advance of plans for connection to establish the electrical interface and operation protocol.

Environmental Regulations and Approvals

It is the responsibility of the proponent of a proposed cogeneration facility of any type to notify the Ontario Ministry of the Environment (MOE) and to comply with the requirements of the Environmental Protection Act (EPA). Depending on site-specific circumstances, other approvals covering planning and building regulations may be required from local governments.

In accordance with Section 8 of the EPA all cogeneration systems require a general Certificate of Approval prior to commissioning. Certificates of Approval are issued by the MOE Director of Approvals, following a detailed review of a formal application and supporting documentation. The review will determine whether operation of the cogeneration system conforms to all EPA regulations, notably EPA Regulation 308, which covers air emission quality.

Approval under EPA Regulation 309 is required for any cogeneration facility which will incinerate wastes (including refuse, wood, waste oil, paper, cardboard, etc.) or will generate wastes (including ash, wastewater, etc.). The MOE Director of Approvals may require a public hearing before issuing an approval for such a facility under Regulation 309, depending on the significance of the potential impacts.

Refuse-fired incinerators which burn over 100 tonnes of refuse per day also require approval under the Environmental Assessment Act. An environmental assessment document containing full consideration of the potential impacts of the proposal and the alternatives, as well as a rationale for the proposal, must be submitted to the Minister of the Environment for approval. A public hearing may be required. Proponents should contact the Director of the MOE's Environmental Assessment Branch for details at:

Ministry of the Environment
7th floor, 135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5
(416) 323-4630

Other Regulations

Depending on site-specific circumstances, other regulations may apply to a cogeneration project. These are briefly described in the following table.

KEY REGULATIONS AFFECTING COGENERATION IN ONTARIO

What is Regulated	Relevant Law	Regulating Agency	Requirements for Compliance
Electrical equipment safety, operation, installation, and connection with grid	Power Corporation Act (Electrical Safety Code)	Ontario Hydro Inspection Branch; Local utility inspectors	Inspection and approval
Operation and installation of boilers and pressure vessels	Operating Engineers Act	Pressure Vessels Safety Branch, Ministry of Consumer and Commercial Relations	Certificate of Registration for plant; Certified operators
Environmental quality (air, water, soil, biota, etc.)	Environmental Protection Act (EPA)	Approvals Branch, Ministry of Environment	Certificate of Approval
Incinerated wastes	EPA Regulation 309	Approvals Branch, Ministry of Environment	Certificate of Approval
Refuse-fired incinerators burning over 100 t/d	Environmental Assessment Act	Environmental Assessment Branch, Ministry of Environment	Approval of environmental assessment of the undertaking
Land-use variance	Local zoning by-law and Official Plan; Planning Act	Local planning department; Municipal council; Ontario Municipal Board (in some cases)	Approval

OWNERSHIP AND FINANCING OPTIONS

Ownership Options

There are a range of potential ownership options available for structuring cogeneration projects, including:

- Standard acquisition and ownership;
- Joint ownership by two or more project participants; and
- Ownership by a third party with the equipment being leased back to the project participants.

The ownership option employed is dependent on the specifics of the particular project. Given that cogeneration involves the consumption of a fuel and the production of both heat and power several project participants may be involved as suppliers of the energy source or as consumers of the energy produced.

Where the project is contained within one organization, special ownership structures are not required although lease financing may be employed.

Financing Options

Financing options include standard debt financing, possibly with low interest loans, standard equipment lease financing, and for larger projects, possibly project financing or a limited partnership approach. Financial institutions are interested in both the financial strength of the organization making the investment in the cogeneration equipment and the financial risks associated with the cogeneration project itself.

The most appropriate approach for a relatively small cogeneration project is to include it in an on-going capital budgeting program. In other words, the cogeneration project is considered to be a small part of a much larger financing program. Financial institutions are thus likely to be more concerned with the owner's overall financial strength than the specific aspects of the cogeneration project.

On the other hand, financial institutions will likely be interested in the specifics of the cogeneration project as well as the owner's overall financial strength for projects that are relatively large in relation to the size of the proponent organization. The areas of potential risk that must be addressed include the market for the energy products produced, the fuel source, the reliability of the cogeneration equipment and the associated capital and operating costs.

For projects with capital costs under $1-million, standard debt or equipment lease financing arranged through the proponents normal financing sources are likely the most appropriate. In addition, energy savings financing firms (listed in Appendix C) may also be interested in financing projects with capital costs as low as $100,000.

Project financing may be appropriate for large schemes with capital costs in excess of $5-million. Under this approach, the cogeneration project becomes a venture in itself and the financing is secured on the basis of the cash flow generated by the project. In order to structure this type of venture, firm long-term contracts for the purchase of fuel and the sale of the energy output are generally required along with firm prices for capital and operating costs.

Cogeneration equipment is eligible for accelerated tax benefits under Capital Cost Allowance Class 34. Items within this class may be subject to a tax write-off in the amount of 25 per cent in the first year of ownership, 50 per cent in the second year, and the remaining 25 per cent in the third year.

Because of these potential tax benefits and the possible benefit of "off balance sheet" financing, larger projects with capital costs in excess of $2 million may benefit from alternative approaches. Appendix C provides a list of major financial institutions which may be interested in financing larger cogeneration projects.

HOW TO OBTAIN FINANCING FOR A COGENERATION PROJECT

What does a financial institution need to know to assess the financial feasibility of your project? Bearing in mind that the requirements vary with each institution, your proposal should include the following:

1. Project Description

Describe the technology used, technical feasibility, ownership structure, energy contracts for purchase of fuel(s) and/or sale of energy, and secured approvals.

2. Risk Identification

Identification of technical, financial, regulatory, and operational factors that might affect cash flows.

3. Cash Flow Analysis

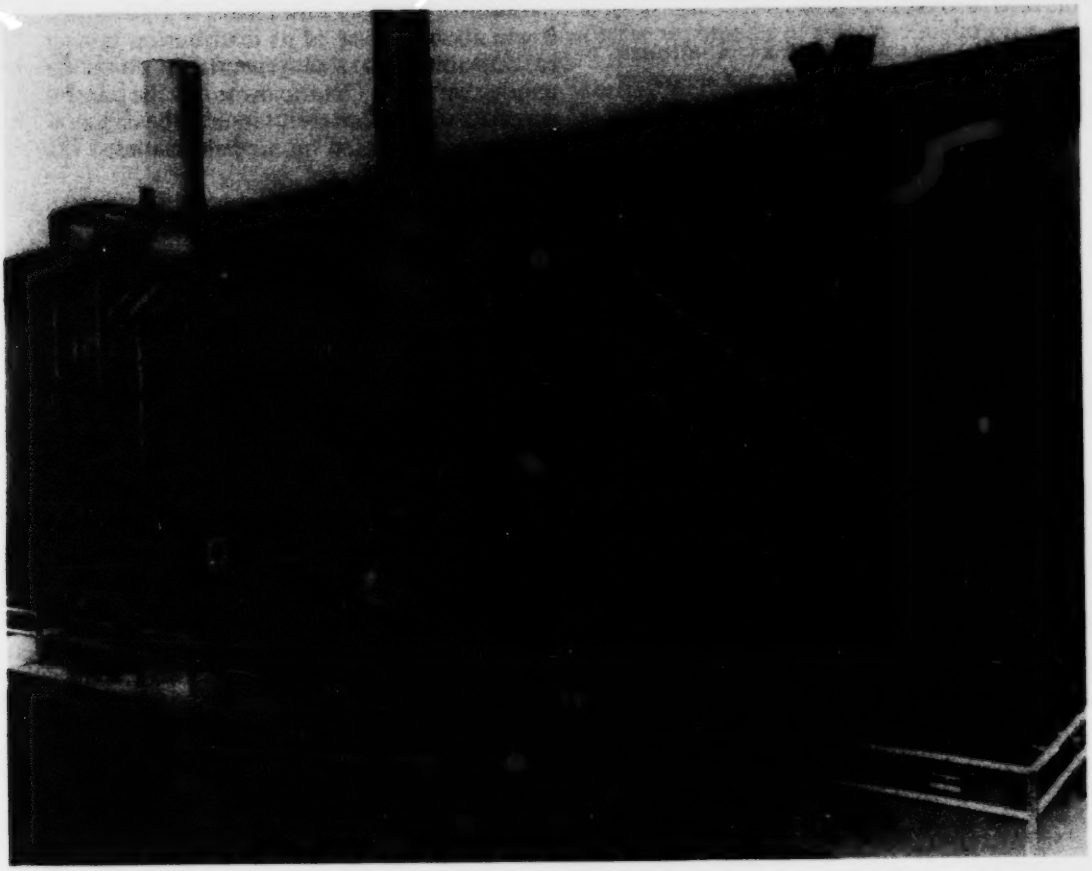
Calculations of revenues, government loans or grants and tax benefits which will offset capital, financing, and operating costs over the service life of the cogeneration facility. Perform "sensitivity analysis" of the project cash flows under different conditions. Particular emphasis should be placed on illustrating how the assumed debt or lease obligations will be serviced.

4. Risk Management

How will the potential risk be managed? Some examples include: demonstrating the financial credibility and commitment of the owner(s) through the size of their equity contribution to the project; documenting the proven track record and reliability of the technology to be used; how capital costs are to be controlled through the type of construction and procurement contracts to be employed; ensuring fuel supply reliability and price stability through long-term fuel supply contracts; and ensuring a reliable stream of revenues through contracts for the sale of electricity and steam or hot water.

5. Proposed Credit Structure

Proposed amount and terms for repayment of loan/equity, together with any other proposed terms and conditions.



Manufactured by Solar Turbines Inc., this Centaur gas turbine cogeneration system operates at a pharmaceutical manufacturing plant. Its electrical output is 3130 kW. It produces steam at a rate of 7,700 kg/hr or 20,900 kg/hr with additional duct burners.

OVERVIEW OF ENERGY CONTRACTS

Energy contracts are a critical factor in determining the commercial and economic viability of a cogeneration project. The nature of these arrangements often has an important bearing on securing the necessary financial resources for the project. Depending upon how the cogeneration project is structured, separate contracts will usually have to be negotiated for both the purchase of input fuel and the sale of surplus generated electrical power and/or steam. In order to manage all financial risks associated with certain energy contracts, appropriate "take-or-pay" clauses may be negotiated to reduce this area of uncertainty. For large and complex arrangements, legal counsel with experience and expertise in energy contracts should be consulted.

Electrical Power Sales

Ontario Hydro has established a commitment to purchase electrical power from private power producers ("parallel generators") in Ontario. If the generation site is within the franchise area of a municipal electric utility, that utility has the first option to purchase the power under its own rates and service conditions. If firm commitments are made regarding minimum continuous supply, a more favourable price can be obtained. This price can be fixed for a ten-year period or set annually. However, if the utility is unwilling or unable to deal with a parallel generator, then, and with its agreement, Ontario Hydro will purchase the power under the following conditions:

- The parallel generator must be located within the power district of Ontario Hydro or the enfranchised areas of municipal utilities supplied by Hydro;
- Only the net power is purchased from the generation site (power requirements at the generator location must be met first);
- All purchases (and wheeling) are subject to rates and service conditions set by Ontario Hydro; and
- Parallel generators must pay all incremental costs (except metering) incurred by Ontario Hydro for connecting their generators to the power system.

The rates paid by Ontario Hydro for the purchase of electrical power are dependent on a number of factors such as the monthly capacity factor (the ratio of average to peak monthly power delivered), when the power is available, and the generating capacity. Purchase rates for large power producers (5 megawatts and over) are negotiated.

Ontario Hydro also offers the service of "wheeling" power. This means that for a fee, it will allow the use of its distribution system to transmit a parallel generator's power to another service in Ontario owned by the parallel generator. This, however, requires the cooperation of any affected municipal utilities.

Sales of Surplus Steam and Hot Water

When selling surplus heat or steam to another party, some of the important issues to consider in negotiating these types of contractual arrangements include:

- The parameters for the delivered heat or steam (quantity, temperature, and pressure);
- The reliability of steam and hot water supply;
- The pattern of the customer's demand; and
- The basis for establishing a selling rate structure, which, from the cogenerator's perspective, would include consideration of potential credits for avoided fuel, plant operating, capital, and financing costs.

Fuel Supply

A broad range of fuels, including wood residues, biogas, municipal solid waste, coal, oil and natural gas can be used in cogeneration.

Natural Gas

Throughout much of Southern Ontario, natural gas (or natural gas periodically supplemented with fuel oil) will likely be the fuel of choice. The major issues to be considered in a gas purchase contract include:

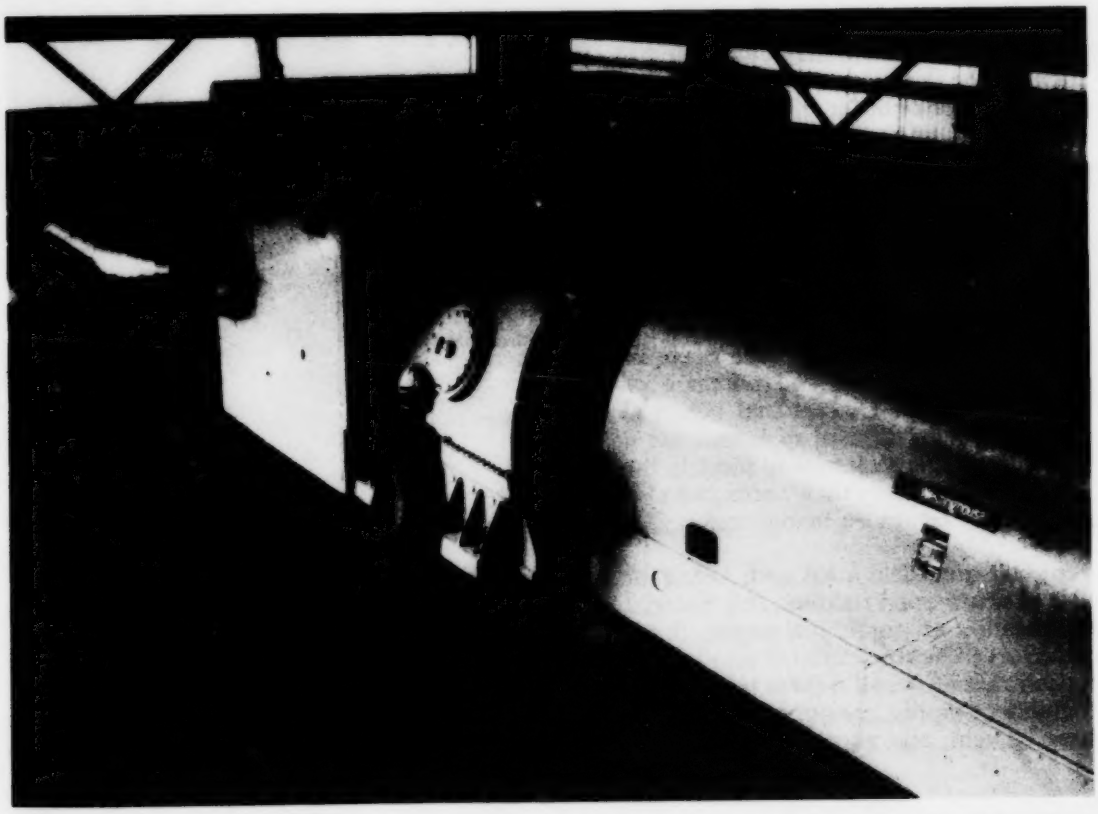
- Firm versus interruptible service;
- Availability of long-term gas contracts;

- Flat rate versus step-rated price structures;
- Minimum and maximum quantities; and
- Variations in demand on a daily, monthly and seasonal basis.

For small cogeneration projects, the gas can be purchased directly from the local gas utility. In this case, there will not likely be a contract. Rather, the pattern of service of a cogeneration project will determine its appropriate rate structure.

Gas utility representatives are generally pleased to explain the various rate structures. Potential cogenerators are advised to investigate the impact that different rate structures will have on the economics of their particular proposal.

Recent deregulation of the gas industry has opened the door for alternative arrangements for consumers of large quantities of natural gas. These alternatives include purchasing gas from a broker in Western Canada or directly from a producer. In either case, approval arrangements have to be made with the pipeline and distribution companies to deliver the gas. It is advisable to retain an experienced independent consultant to assist in identifying and conducting initial negotiations with a suitable supplier, whether this involves a direct purchase of gas from a producer or indirect purchase through a broker.



A Westinghouse 60 MW extraction/condensing set used in a chemical manufacturing plant.

Wood Residues

For projects situated in areas with abundant supplies of waste wood residues, this material may be the most economic fuel source. Some of the factors to be considered in arranging a supply contract for wood residue fuel include its reliability of supply, consistency of quality, moisture content, and particle size.

Other Fuels

Projects using biogas, municipal solid waste, or coal as fuel are generally unique and highly site-specific. In these projects, as with other cogeneration projects, reliability of supply and consistency of fuel quality are important aspects to be considered in the supply agreements.

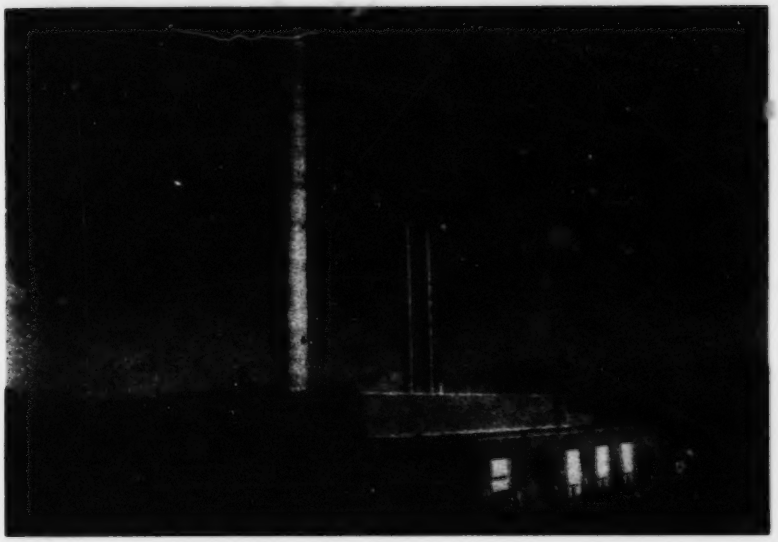
For fuels such as municipal solid waste, where it is recognized that there may be significant variations in the energy content of the fuel, it is important to account for this variability by including bonus and penalty clauses in the fuel supply contract.

Summary

In summary, energy contracts specifying prices, terms and conditions—whether for sale or purchase—play a critical part in determining project viability. Generally, a wide range of options for both the sale and purchase of energy are available. Owners and potential owners are strongly advised to investigate a range of contracting strategies to identify the approach that best meets their needs and also maximizes their return on investment.

For projects situated in areas with abundant supplies of waste wood residues, this material may be the most economic fuel source. Some of the factors to be considered in arranging a supply contract for wood residue fuel include its reliability of supply, consistency of quality, moisture content, and particle size.

PROJECT EXAMPLES

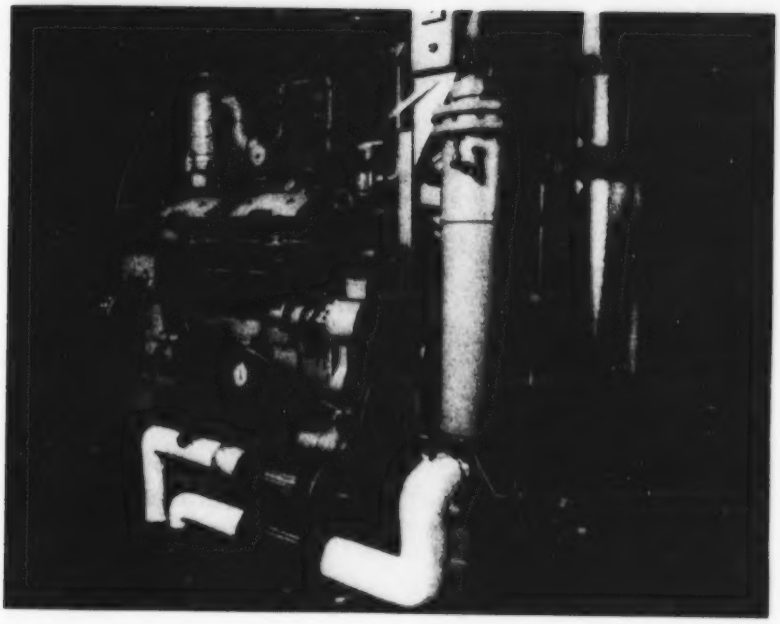


Energy-from-waste plant, Victoria Hospital, London, Ontario.

PROJECT NAME	**VICTORIA HOSPITAL ENERGY-FROM-WASTE PLANT**
LOCATION	London, Ontario
OWNER	Victoria Hospital Corporation
TURNKEY CONTRACTOR (Design Build)	Fenco Engineers Inc.
MAJOR SUPLIER	Petro-Sun International (incinerator supplier)
YEAR IN-SERVICE	1987
FUEL TYPE	Solid waste (272 tonne/day)
SYSTEM DESCRIPTION	
Cogeneration Operating Cycle	Topping cycle
Prime Mover	Condensing turbine with steam extraction
Generator	Synchronous (7.5 MVA)
Utility Connection	Yes
RATED CAPACITY	Electrical: 2.5 MW @ Thermal output: 55 million BTU/hr (max)
	Electrical: 5.0 MW @ Thermal output: 23 million BTU/hr (min)
OPERATIONAL STRATEGY	Thermal load following, although steam can be diverted to electrical power generation in the event of a power outage. Export-import load levelling with respect to electricity.

LOAD DISPLACEMENT	At full capacity, satisfies all thermal demand. Electrical demand always exceeds power generated.
POWER SALES TO ONTARIO HYDRO/ LOCAL ELECTRICAL UTILITY	Plant is connected to electricity system to allow sales of electricity.
THERMAL APPLICATIONS	Space heating and humidification, air conditioning through absorption chillers.
FINANCING	
Owner	60%
Provincial Government	20%
Federal Government	20%
COSTS	
Capital	$27 million (1986)
Annual Operating	$2.7 million (1987)
ESTIMATED ENERGY SAVINGS	$2 million/year
CONTACT	Plant Manager (519) 685-8179

PROJECT EXAMPLES



The cogeneration package at the Peterborough Pollution Control Centre.

PROJECT NAME	**PETERBOROUGH POLLUTION CONTROL CENTRE**
LOCATION	Peterborough, Ontario
OWNER	Johnson Controls
ENGINEERING/DESIGN	MacLaren Engineers
CONSTRUCTION	Adamson and Dobbin Ltd. (Peterborough)
OPERATION	Staff-operated; Atlas Polar maintenance contract for Johnson Controls
YEAR IN-SERVICE	1986
FUEL TYPE	Digester gas (65% methane)
SYSTEM DESCRIPTION	
Cogeneration Operating Cycle	Topping cycle
Prime Mover	Spark-ignition gas engine (Waukesha)
Exhaust Gas Boiler	Water-tube, hot water, 90°C (Maxim)
Generator	Induction, 250 kVA, 600 V x 3ph x 60 Hz
Utility Connection	No (internal)

RATED CAPACITY	200 kW electrical, 335 kW thermal
OPERATIONAL STRATEGY	Electrical base loading. (Excess thermal energy is wasted when necessary)
LOAD DISPLACEMENT	Electricity—approx. 70% Thermal—80 to 100% (seasonal)
POWER SALES TO ONTARIO HYDRO/ LOCAL ELECTRICAL UTILITY	No
THERMAL APPLICATIONS	Process heating (digester heating) and space heating (seasonal)
OWNERSHIP OPTION	Savings financing. (Debt repayment based on rate equal to annual energy savings. Full ownership reverts to the City at debt retirement).
FINANCING	
Owner	82.3 % (Johnson Controls)
Federal Government	17.7 % (FIRA Grant)
COSTS	
Capital	$275,000 (1986)
Annual Operating	$ 6,000 (1987) (fuel is free).
ENERGY COST SAVINGS	$ 50,000/year
CONTACT	Johnson Controls Ltd. 7400 Birchmount Markham, Ontario L3R 5V4 (416) 494-1575

PROJECT EXAMPLES

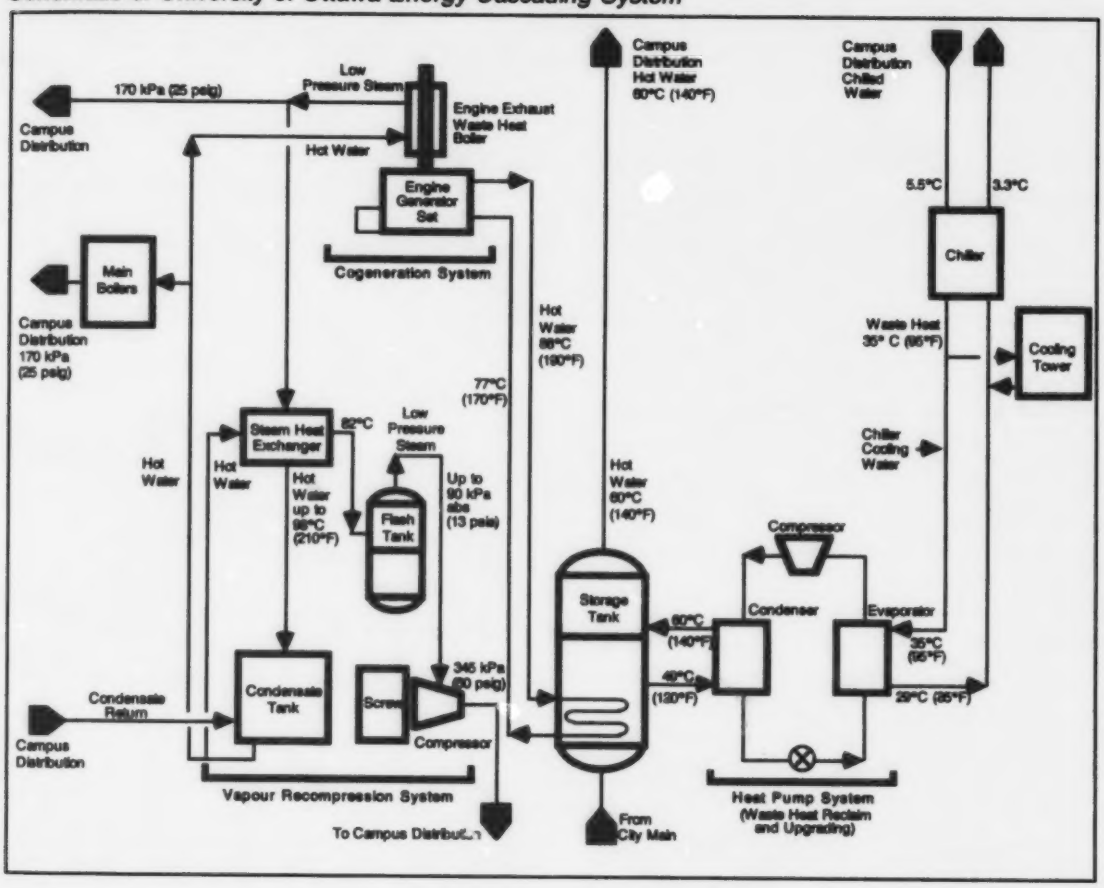
Dow Chemical Canada Inc.'s cogeneration installation Sarnia, Ontario.

PROJECT NAME	**DOW CHEMICAL CANADA INC.** **Cogeneration Combined Cycle**
LOCATION	Sarnia, Ontario
OWNER	Dow Chemical Canada Inc.
ENGINEERING/DESIGN	Dow Chemical Canada Engineering Dept. Turbine-generator: General Electric Boiler: Foster Wheeler Steam turbine: Westinghouse Canada Inc.
CONSTRUCTION	General Contractor—Dow Chemical Canada Engineering Dept. Gas Turbine-generator: General Electric Boiler: Foster Wheeler Steam turbine: Westinghouse Canada Inc.
OPERATION	Staff-operated
YEAR IN-SERVICE	1963—Steam turbine generator units 1972—Gas turbine generator units with Heat Recovery Steam generators
FUEL TYPE	Natural gas with gasified butane as back-up
SYSTEM DESCRIPTION	
Cogeneration Operating Cycle	Combined cycle (topping cycle)
Prime Mover	Two General Electric Frame 7B, 55 MW, gas turbine-generators; Two Westinghouse Canada 30 MW steam turbine generators.
Generator	Two G.E. synchronous, hydrogen cooled generators 64 MVA, 14.4 KV., 85 P.F. Two Westinghouse synchronous hydrogen cooled generators 33 MVA, 14.4 KV .85 P.F.
Utility Connection	230 KV connection with Ontario Hydro
TOTAL RATED CAPACITY	161 MW

TOTAL RATED CAPACITY	161 MW
OPERATIONAL STRATEGY	Base load to provide electric and steam energy requirements for the Chemical Manufacturing Process plants
LOAD DISPLACEMENT	Electrical: 85 % of annual process demand Thermal: 100% of annual process demand
POWER SALES TO ONTARIO HYDRO	Energy sale based on surplus capacity. Avg. sale: 3,650 KW hrs/month
THERMAL APPLICATIONS	Process steam • 68,000 kg/hr @ 3100 kPa (302°C) • 215,000 kg/hr @ 12,300 kPa (246°C) • 170,000 kg/hr @ 300 kPa (154°C)
CYCLE OVERALL EFFICIENCY	83% (HHV)
OWNERSHIP OPTION	Standard acquisition and ownership
FINANCING (Owner)	100%
COSTS (Capital)	1963—$4,800,000 1972—$16,000,000
ESTIMATED ENERGY COST SAVINGS	37% of total/year
CONTACT	Mr. J.P. Zanyk Project Specialist Dow Chemical Canada Inc. P.O. Box 1012 Sarnia, Ontario N7T 7K7

PROJECT EXAMPLES

Schematic of University of Ottawa Energy Cascading System



PROJECT NAME	**UNIVERSITY OF OTTAWA**
LOCATION	Ottawa, Ontario
OWNER	University of Ottawa
ENGINEERING/DESIGN	Cogeneration Associates Ltd.
OPERATION	University of Ottawa Staff
YEAR IN-SERVICE	1984
FUEL TYPE	Natural Gas

SYSTEM DESCRIPTION	
Cogeneration Operating Cycle	Topping Cycle
Prime Mover	600 kW Reciprocating Engine (Waukesha)
Generator	Induction
Utility Connection	Yes
RATED CAPACITY	600 kW (electrical)
OPERATIONAL STRATEGY	Base Loading as part of an energy cascading design
LOAD DISPLACEMENT	Electrical: 3860 MWH (6% of total load) Thermal: 28,000 MCF (equivalent)
POWER SALES TO ONTARIO HYDRO/ LOCAL ELECTRICAL UTILITY	No
THERMAL APPLICATIONS	Cooling water jacket used to heat hot water tank from 49°C to 60°C. Engine exhaust used to heat small boiler for production of lowpressure steam. Steam is used in kitchens and laboratories (refer to diagram above).
FINANCING	
Owner	47%
Provincial Government	36%
Federal Government	17%
COSTS	
Capital	$860,000 (1984) for total cascading system
Annual Operating	$2,038,400 for total cascading system ($/1987)
EST. ENERGY COST SAVINGS	$265,000 per year
CONTACT	Robert Walterson, P. Eng. Ministry of Energy Industrial Conservation 56 Wellesley Street W. Toronto, Ontario M7A 2B7 (416) 965-9513

SOURCES OF AVAILABLE ASSISTANCE

There are a number of private and governmental sources of assistance for the potential cogenerator. The following is a brief description of some of the services available.

Ontario Ministry of Energy

The Ministry of Energy provides assistance for the implementation of proven cogeneration technologies through a number of programs. In addition to financial assistance, it provides information about various types of energy technologies and services that are on the market. For assistance on how to obtain more detailed information about related government support programs, financing, and approvals, contact:

Program Advisor, Cogeneration
Alternative Energy Development Section
Ontario Ministry of Energy
8th Floor, 56 Wellesley Street West
Toronto, Ontario
M7A 2B7
(416) 965-0463
Long distance toll-free, call operator for Zenith 80420

Industrial Energy Services Program

This program can help potential cogenerators to assess the feasibility of a cogeneration project and to cover some of the project engineering costs. To qualify, an Ontario-based manufacturing firm must spend more than $50,000 annually on energy. The program has three components:

- A comprehensive energy audit of the plant involving a detailed evaluation of the energy efficiency improvement opportunities available. This free service is conducted by a private consultant selected by the Ministry.

- A feasibility analysis grant of up to 75 per cent of the lump sum costs to develop the energy efficiency opportunities into "budget grade" information. The maximum contribution is $70,000, based on site annual energy cost levels. Eligible applicants choose their own engineering consultants (see Appendix A).

- A project engineering grant paying up to 25 per cent of the cost of drawings and specifications required for implementing an energy project identified through the feasibility analysis. The maximum grant contribution is $70,000, based on site annual energy cost levels. Eligible applicants select a certified engineering consultant on their own.
  Contact:

  Program Advisor
  Industrial Energy Services Program
  Ontario Ministry of Energy
  10th Floor, 56 Wellesley Street West
  Toronto, Ontario
  M7A 2B7
  (416) 965-1308
  Long distance toll-free, call operator for Zenith 80420

Enerloan

Enerloan is a five-year Ministry of Energy program administered by the Ontario Development Corporation to provide low-interest, guaranteed loans to help public institutions undertake fuel conversions and energy efficiency improvements in existing buildings. A maximum loan of $1.5 million is available per project, covering 75 per cent of the first $400,000 of project costs and up to 50 per cent for the balance. Interest rates are subsidized by the Ministry. Contact:

Program Advisor
Enerloan Program
Ontario Ministry of Energy
Public and Commercial Buildings Section
10th Floor, 56 Wellesley Street West
Toronto, Ontario
M7A 2B7
(416) 963-3035 (social services facilities)
(416) 965-1504 (hospitals, colleges, universities)
Long distance toll-free; call operator for Zenith 80420

The Northern Ontario Wood Energy Program

In Northern Ontario, any commercial or industrial use of wood residues to produce thermal or electrical power is eligible for assistance under the Northern Ontario Wood Energy Program. Started in July, 1986, the three-year program will expire in March, 1989. Financial assistance is administered by the Northern Ontario Development Corporation, while technical and legal advice is provided by the Ministry of Energy.

Under the program, the Government contributes up to 25 per cent of total capital costs of a project, limited to the amount required to raise the after-tax return on equity to approximately 20 per cent. Interest rate subsidies for commercial loans are also available.
Contact:

Program Advisor
Northern Ontario Wood Energy Program
Ontario Ministry of Energy
8th Floor, 56 Wellesley Street West
Toronto, Ontario
M7A 2B7
(416) 965-0443
Long distance toll-free, call operator for Zenith 80420

Energy from Waste Program

This is a five-year capital assistance program, begun in 1987, providing grants to municipalities and grants or loans to private companies for the cost of land, buildings, and equipment used for facilities that use refuse to produce electricity, steam, or hot water. Eligible wastes include municipal refuse, landfill gas, sludge, wood residues, industrial and commercial solid wastes, and rubber tires.

Support, however, will not exceed 15 per cent of eligible capital costs, to a maximum of $6-million per project, and will be limited for the private sector to the amount required to raise the after-tax return on equity to 20 per cent. Contact:

Program Advisor
Energy From Waste Program
Ontario Ministry of Energy
8th Floor, 56 Wellesley Street West
Toronto, Ontario
M7A 2B7
(416) 965-0443
Long distance toll-free, call operator for Zenith 80420

Ontario Hydro

Ontario Hydro has a corporate policy commitment to purchase electrical power from private power producers in Ontario subject to rate affordability and standard service conditions. The present policy provides for three main activities:

- The purchase of electrical power from parallel generators as a resource to the power system (see "Overview of Energy Contracts);
- Wheeling of electrical power for parallel generators to other sites in Ontario owned by the parallel generator; and
- The provision of technical assistance on a cost recovery basis when the assistance is not readily available in the marketplace.

Additional information on Ontario Hydro's purchase and contract conditions and on the technical requirements for connection can be obtained from the "Manager-Marketing" in the six regional offices of Ontario Hydro (listed in Appendix D).

Municipal Electric Power Utilities

At present, most local municipal utilities do not have in place standard purchasing agreements for cogenerated power.

The Municipal Electric Association (MEA), an organization representing 319 power utilities in Ontario, is currently developing a standard agreement and policy on cogeneration for all utilities. For the potential cogenerator, the MEA will provide information on a particular local utility, facilitate communication between the cogenerator and the utility, and provide assistance in the development of a specific agreement for the sale of electrical power. It can also provide the name of the utility and a local contact person responsible for the area in which the cogeneration site is to be located, should there be some difficulty in obtaining this information. Contact:

Municipal Electric Association
20 Eglinton Avenue West
P.O. Box 2004
Suite 1301
Toronto, Ontario
M4R 1K8
(416) 483-7755

Natural Gas Utilities

The Ontario Natural Gas Association (ONGA) is an industry organization which represents the natural gas industry in Ontario and comprises over 300 company and individual members. The membership includes three large gas utilities operating in Ontario, namely Consumers Gas, Union Gas, and ICG Utilities (Ontario) Ltd. Because these are separate corporate entities, each utility offers different kinds of support for cogeneration projects.

In general, however, all gas utilities, and ONGA itself, are very supportive of cogeneration. These technologies are seen as a method of increasing the efficiency of energy use in the Province, thereby making our industries more competitive in the international marketplace.

To develop this opportunity, the gas industry provides a number of services to prospective cogenerators, ranging from guiding the client through the array of available government assistance programs, to providing assistance for conducting feasibility analyses, to providing capital assistance in some form where there are mutual benefits to the gas utility and the cogenerator. Since the type of assistance will vary widely from one gas utility to the next, it is recommended that a representative of the gas utlity enfranchised for your area be contacted for further advice.

ONGA has developed a reservoir of cogeneration expertise by establishing a Cogeneration Task Force composed of utility representatives. Since its inception, this group, which maintains close contact with Ontario industrial gas customers, has ensured that the policies developed by ONGA and the member utilities are timely and appropriate. The task force plays a major role in identifying key issues. For further information contact:

Ontario Natural Gas Association
77 Bloor Street West
Toronto, Ontario
S 1M2
(416) 961-2339

or a representative of a gas utility enfranchised for your area (listed in Appendix D).

Federal Government

Energy, Mines and Resources Canada has a number of programs in place to encourage the development of conservation and oil substitution technologies. Most of the assistance, however, is in research and development and is provided through the Industrial Energy Division of the Department's Energy Conservation and Oil Substitution Branch.

Industry Energy Research and Development (IERD) Program

IERD provides financial support for Canadian companies engaged in energy conservation research and development aimed at products, processes, or systems that will increase the efficiency of energy use.

It will contribute up to 50 per cent of the costs of an eligible project. The cost-sharing ratio will depend on the degree of risk, the magnitude of potential energy savings, and the degree to which the technology developed can be used by other companies. Capital costs for buildings, machinery and laboratory equipment are not allowable. Contact:

IERD Secreteriat
Industrial Energy Division
Energy Conservation and Oil Substitution Branch
Department of Energy, Mines and Resources
580 Booth Street
Ottawa, Ontario
K1A 0E4
(613) 996-6593

Accelerated Capital Cost Allowance Class 34

This incentive is an accelerated capital cost allowance designed to encourage business and industry to use energy efficiently, to decrease its dependence on oil, and to switch to renewable energy sources.

Stated simply, it is a "fast write-off" for machinery and equipment which form part of a system as listed in Class 34 of Schedule II, Capital Cost Classes of the Income Tax Regulations. Established in 1976, and extended indefinitely in December, 1985, Class 34 provides the only major tax incentive for the installation of innovative energy technologies, such as cogeneration.

A capital cost allowance can be claimed on a Class 34 asset over a three year period. The maximum claims are 25 per cent of eligible capital costs in the first year, 50 per cent in the second year, and 25 per cent in the third year.

Without this accelerated capital cost allowance, the rates applied to these types of assets would normally be either 6 per cent or 20 per cent calculated on a declining balance basis.

In summary, the chief benefit of investing in Class 34 assets is that profitable enterprises can defer some of their tax obligations and, thus, pay less tax during the first three years of ownership of the assets.

To qualify for the fast write-off, an asset must be acquired by a Canadian taxpayer for use in a business in Canada and must also be certified by the Minister of Energy, Mines and Resources. The February 1988 federal budget amended the rules governing Class 34 such that accelerated tax write-offs can be claimed only by the actual user of the equipment. The change prevents nontaxable entities such as municipalities and institutions from reducing equipment costs through tax-base lease financing.

An application form for certification (or for "prior opinion") can be obtained from:

Tax Incentive Programs Secreteriat
Energy Conservation Branch
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ontario
K1A 0E4
(613) 995-1118

If possible, include with your application a simple block diagram or schematic of the equipment or system, a list of installed capital costs and a brief explanation of the system. These will speed up the processing of your application.

APPENDIX A: CONSULTANTS

For information on engineering consulting firms in Ontario and for guidelines on selecting consulting engineers, contact:

Consulting Engineers of Ontario
Suite 403
86 Overlea Boulevard
Toronto, Ontario
M4H 1C6
(416) 425-8027

For information on out-of-province engineering consultants, contact:

Association of Consulting Engineers of Canada
Suite 616
130 Albert Street
Ottawa, Ontario
K1P 5G4
(613) 236-0569

The following are a list of engineering consultants in Ontario listed under "District Heating and Cogeneration" in the 1987 CEO and ACEC directories:

Acres International Ltd.
480 University Avenue
Toronto, Ontario M5G 1V2
(416) 595-2000

H. H. Angus & Associates Ltd.
1127 Leslie Street
Don Mills, Ontario M3C 2J6
(416) 449-8200

E.R. Broughton Associates Ltd.
199 Blythwood Road
Toronto, Ontario M4N 1A5
(416) 487-8474

M. R. Byrne & Associates
480 Guelph Line
Burlington, Ontario L7R 3M1
(416) 632-8044

Canadian International Power Services Inc.
2200 Argentia Road
Mississauga, Ontario L5N 2K7
(416) 858-8020

Cogeneration Associates Ltd.
2 Jane Street, Suite 202
Toronto, Ontario M65 4W3
(416) 762-7259

Conestoga-Rovers & Associates Ltd.
651 Colby Drive
Waterloo, Ontario N2V 1C2
(519) 884-0510

M. M. Dillon Ltd.
Box 1850 Station "A"
Willowdale, Ontario M2N 6H5
(416) 229-4646

The ECE Group Ltd.
205 Lesmill Road
Don Mills, Ontario M3B 2V1
(416) 449-1030

Fodor Engineering Ltd.
275 Duncan Mill Road
Don Mills, Ontario M3B 2Y1
(416) 449-2880

Gesmec Inc.
368 Slater Street, Suite 201
Ottawa, Ontario K1R 5C1
(613) 234-6280

Giffels Associates Ltd.
30 International Boulevard
Toronto, Ontario M9W 5P3
(416) 675-5950

Goodkey, Weedmark & Associates Ltd.
1749 Woodward Drive
Ottawa, Ontario K2C 0P9
(613) 727-5111

Gore & Storrie Ltd.
1670 Bayview Avenue
Toronto, Ontario M4G 3C2
(416) 485-7715

Interplan Ltd.
75 The Donway West, Suite 1408
Don Mills, Ontario M3C 2E9
(416) 447-9146

JAD Engineering Ltd.
111—7th Street East
Owen Sound, Ontario N4K 1H6
(519) 371-9330

KWM Engineers Ltd.
50 Gervais Drive
Don Mills, Ontario M3C 1Z3
(416) 444-6656

W. P. London & Associates Ltd.
4056 Dorchester Road, P.O. Box 1025
Niagara Falls, Ontario L2E 6V9
(416) 356-1543

J. Lunde & Associates Ltd.
900 Lady Ellen Place
Ottawa, Ontario K1Z 5L5
(613) 725-1011

MacLaren Plansearch Inc.
2235 Sheppard Avenue East
Willowdale, Ontario M2J 5A6
(416) 756-3866

MacLaren Engineers Inc.
2235 Sheppard Avenue East
Willowdale, Ontario M2J 5A6
(416) 756-4919

Marshall Macklin Monaghan Ltd.
275 Duncan Mill Road
Don Mills, Ontario M3B 2Y1
(416) 449-2500

E. F. Marston Engineering Ltd.
17 Ontario Street, Suite 6
Port Hope, Ontario L1A 3V9
(416) 885-2497

M. E. L. Consultants Ltd.
230 Sheppard Avenue East
Willowdale, Ontario M2N 3A9
(416) 229-6070

The Mitchell Partnership Ltd.
59 Mobile Drive
Toronto, Ontario M4A 1H8
(416) 751-3733

Mitchell, Pound & Bradock Ltd.
4 Church Street
Richmond Hill, Ontario L4C 1W2
(416) 883-1500

Monteith, Ingram, Graham Ltd.
360 Centre Street
Petrolia, Ontario N0N 1R0
(519) 882-2140

Planmac Consultants Ltd.
3055 Lakeshore Boulevard West
Toronto, Ontario M8V 1K6
(416) 259-0566

Proctor & Redfern Ltd.
45 Greenbelt Drive
Don Mills, Ontario M3C 3K3
(416) 445-3600

Project Planning Ltd.
1 Yonge Street, Suite 1100
Toronto, Ontario M5E 1E5
(416) 925-1411

J. L. Richards & Associates Ltd.
864 Lady Ellen Place
Ottawa, Ontario K1Z 5M2
(613) 728-3571

Robertson Nickerson Ltd.
75 Albert Street, Suite 610
Ottawa, Ontario K1P 5E7
(613) 238-4625

SNC Inc.
20 Toronto Street, Suite 800
Toronto, Ontario M5C 2B8
(416) 362-3911

Totten Sims Hubicki Associates Ltd.
1500 Hopkins Street
Whitby, Ontario L1N 2C3
(416) 668-9363

Triton Engineering Services Ltd.
51 Townline
Orangeville, Ontario L9W 1V1
(519) 941-0330

Walter, Fedy, McGarger, Hachborn
546 Belmont Avenue West, P.O. Box 368
Kitchener, Ontario N2G 3Y9
(519) 576-2150

W. L. Wardrop & Associates Ltd.
595 Squier Street
Thunder Bay, Ontario P7B 4A7
(807) 345-5453

APPENDIX B: EQUIPMENT MANUFACTURERS AND SUPPLIERS

The following lists show major representative firms only.
City locations and telephone numbers for supplier in or nearest to Ontario are for head office (ask for the nearest distributor). Where only the manufacturer is identified, city location and telephone number for head office is listed. For manufacturers outside of North America, contact the appropriate trade or consular office listed in the telephone directory.

*Supplier with significant Canadian content.

PRIME MOVERS

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Smaller Gas Engines (to 75 kW nom.)			
Fiat	Fiat Products Toronto, Ont. (416) 492-5954	Waukesha/ Dresser	Atlas Polar* Toronto, Ont. (416) 751-7740
Onan	Cummins Ontario* Toronto, Ont. (416) 621-9921	Winpower	Sommers Motor Gen. Sales Tavistock, Ont. (519) 655-2396
Intermediate Gas Engines (to 1500 kW nom.)			
Caterpillar	Crothers* Toronto, Ont. (416) 667-5511	Superior Engines	Cooper Energy Services* Mississauga, Ont. (416) 678-2030
Cummins Engine	Cummins Ontario* Toronto, Ont. (416) 621-9921	Waukesha/ Dresser	Atlas Polar* Toronto, Ont. (416) 751-7740
MEP Industries	Houston, TX (713) 896-9455		
Larger Gas Engines (to 3000 kW nom; gas fuel only)			
Cooper Bessemer	Cooper Energy Services* Mississauga, Ont. (416) 678-2030	Enterprise (Transamerica Delaval)	Delaval Turbine Canada Mississauga, Ont. (416) 678-2030

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Larger Gas Engines (to 3000 kW nom; gas fuel only)...cont'd.			
Nordberg	Cooper Energy Services Mississauga, Ont. (416) 678-2030	Waukesha/ Dresser (Sluzer)	Atlas Polar Toronto, Ont. (416) 751-7740
Larger Gas Engines (to 6000 kW nom; dual-fuel - 90% natural gas-10% fuel-oil)			
Cooper Bessemer	Cooper Energy Services* Mississauga, Ont. (416) 678-2030	Mirrlees Blackstone	Hawker-Siddeley Canada Toronto, Ont. (416) 362-2941
Enterprise (Transamerica Delaval)	Delaval Turbine Canada Mississauga, Ont. (416) 678-6141	Nordberg	Cooper Energy Services* Misissauga, Ont. (416) 678-2030
General Motors Diesel	Midwest Power Products* Winnipeg, Man. (204) 452-8244	Ruston	GEC Diesels Toronto, Ont. (416) 622-3060
Smaller Diesel Engines (to 75 kW nom.)			
Avco Lycoming Stratford Div.	Stafford, CT (203) 385-2000	Isuzu	Isuzu Diesels Toronto, Ont. (416) 259-3281
Continental	AJ Shearer Toronto, Ont. (416) 241-8515	Lister	Lister-Petter Canada Toronto, Ont. (416) 239-2321
Deutz	Armbro Diesel Brampton, Ont. (416) 457-7700		
Ford Motor Co. Industrial Diesel	M-K Power Products Mississauga, Ont. (416) 677-2011		

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Smaller Diesel Engines (to 75 kW nom.)...cont'd.			
Onan	Cummins Ontario* Toronto, Ont. (416) 621-9921	Wisconsin (Consolidated Energy Systems)	Thousand Oaks, CA (805) 497-3905
Perkins	Concord Diesel Mississauga, Ont. (416) 678-9330		
John Deer	Harper Detroit Diesel Toronto, Ont. (416) 751-7740		
Intermediate Diesel Engines (to 1500 kW nom.)			
Caterpillar	Crothers* Toronto, Ont. (416) 667-5511	. Hercules . Fairbanks Morse . White	Peel Engine Service Mississauga, Ont. (416) 677-0281
Cummins Engine	Cummins Ontario* Toronto, Ont. (416) 621-9921	Mitsubishi	Atlas Polar* Toronto, Ont. (416) 751-7740
Detroit Diesel Allison (General Motors)	Harper Detroit Diesel* Toronto, Ont. (416) 259-3281	Waukesha Volvo	Atlas Polar* Toronto, Ont. (416) 751-7740
Deutz	Armbro Diesel Brampton, Ont. (416) 457-7700		
. Dorman . Paxman . Ruston	GEC Diesels Toronto, Ont. (416) 622-3060		
. Mirrelees . Blackstone	Hawker-Siddeley Can., Toronto (416) 362-2941		

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Larger Diesel Engines (to 3000 kW nom.)			
Alco Power	Bombardier* Montreal, PQ (514) 253-7333	Man B & W	Man GHH (Canada) Pte. Claire, PQ (514) 694-3000
Cooper Bessemer	Cooper Energy Services* Mississauga, Ont. (416) 678-6141	. Mirrlees . Blackstone	Hawker-Siddeley Canada Toronto, Ont. (416) 362-2941
Deutz	Armbro Diesel Brampton, Ont. (416) 457-7700	Waukesha/ Dresser	Atlas Polar* Toronto, Ont. (416) 751-7740
Enterprise (Transamerica Delaval)	Delaval Turbine Canada Mississauga, Ont. (416) 678-6141	Nordberg	Cooper Energy Services* Mississauga, Ont. (416) 678-6141
General Motors Diesel	Midwest Power Products Winnipeg, Man. (204) 452-8244	SEM Pielstick	APE Canada Mississauga, Ont. (416) 821-1300

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Gas Turbines (to 3000 kW nom.)			
Garrett Airsearch	Torrance, CA (213) 323-9500	Pratt & Whitney	Pratt & Whitney Canada* Longueuil, PQ (514) 677-9411
Kawasaki	Cullen Canadian Kirkland, PQ (514) 694-7733	Ruston Gas Turbines	GEC Diesels Toronto, Ont. (416) 622-3060
Kongsberg (Dresser)	Houston, TX (713) 466-6200	Skinner Engine (Banner Industries)	Erie, PA (814) 454-7103
Norwalk Turbo	Latham, NY (518) 783-1625	Solar Turbines	Solar Turbines* Canada Calgary, Alta. (403) 261-2640
Power Systems (United Technologies)	Farmingham, CT (203) 677-3211	Turbonetics Energy	Latham, NY (518) 783-2552

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
	Gas Turbines (to 80,000 kW nom.)		
Allison Gas Turbine (General Motors)	Cullen Canadian Kirkland, PQ (514) 694-7733	Cooper Bessemer	Cooper Energy Services Mississauga, Ont. (416) 678-2030
Brown Boveri Turbomachinery	Brown Boveri Howden Toronto, Ont. (416) 752-7310	Curtiss-Wright	Curtiss-Wright Canada Mississauga, Ont. (416) 625-6557
Clark (Dresser)	Dresser Canada Clark Division Calgary, Alta. (403) 255-3437	General Electric	Gas Turbine Division Schenectady, NY (518) 385-4210
Hispano-Suiza (Spain)	-	Rolls Royce	Rolls Royce Canada Lachine, PQ (514) 631-3541
Kraftwerk Union (West Germany)	-	Ruston Gas Turbine	GEC Diesels Toronto, Ont. (416) 622-3060
Mitsui	Mitsui Canada Toronto, Ont. (416) 865-0370	Sulzer Brothers	Sulzer Canada Pte. Claire, PQ (514) 695-8320
Nuovo Pignone (Italy)	-	Turbo Power (United Technologies)	Palm Beach Gardens, FL (305) 863-0528
Pratt & Whitney*	Pratt & Whitney Canada Longueuil, PQ (514) 677-9411	Westinghouse Canada*	Hamilton, Ont. (416) 528-8811

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
Steam Turbines (to 100,000 kW nom.)			
ASEA/Brown Boveri	ASEA Mississauga, Ont. (416) 677-0630 Brown Boveri Scarborough, Ont. (416) 759-4465	Elliott (Carrier)	Jeanette, PA (412) 527-2811
Dresser Rand (Terry Turbodyne Turbines)	McRae Engineering Toronto, Ont. (416) 422-3735	Fuji (Japan)	-
Coppus Engineering	Affiliated Engineering Equipment Mississauga, Ont. (416) 624-9751	General Electric	Schenectady, NY (518) 385-4210
Transamerica Delaval	Delaval Turbine Canada Mississauga, Ont. (416) 678-6141	Ingersoll-Rand	Houston, TX (713) 467-2221
Shin-Nippon (Japan)	Bouvet San Anselmo, CA (415) 453-7288	Trane (Murray Steam Turbines)	La Crosse, WI (608) 787-3630
Skinner Engine (Banner Industries)	Erie, PA (814) 454-7103	Westinghouse Canada*	Hamilton, Ont. (416) 528-8811
Thermo Electron	Energy Systems Division Walton, MA (617) 890-8700		
Steam Engines (Reciprocating)			
Spilling Steam Moter (West Germany)	-		

ELECTRICAL POWER AND CONTROL EQUIPMENT

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
	Synchronous Generators		
Brown Boveri	Brown Boveri Howden* Toronto, Ont. (416) 752-7310	Ideal Electric	Mansfield, OH (419) 522-3611
English Electric	GEC Diesels Toronto, Ont. (416) 622-3060	Kato Engineering	Mankato, MN (507) 625-4011
General Electric	Cdn. General Electric Peterborough, Ont. (705) 748-8486	Leroy-Somer	Leroy-Somer Canada Mississauga, Ont. (416) 624-2733
Westinghouse	Westinghouse Canada Hamilton, Ont. (416) 528-8811		
	Induction Generators		
Kato Engineering	Mankato, MN (507) 625-4011	Leroy-Somer	Leroy-Somer Canada Mississauga, Ont. (416) 624-2733
	Eng-Gen Set Controls		
Woodward Governor	Ft. Collins, CO (303) 482-5811		
	(Speed governors, synchronization systems, sequencing, alarm anunciators, computer monitoring and diagnostics)		
	Frequency Control Devices		
Basler Electric	Highland, IL (618) 654-2341		

EXHAUST GAS BOILERS

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
	Smaller Exhaust Gas Boilers		
Beckett	Blenkhorn & Sawle* St. Catharines Ont. (416) 684-9251	CIN Tube Boilers*	Mississauga, Ont. (416) 671-4600
Cleaver Brooks	Johnson Paterson Markham, Ont. (416) 499-4822	Sims	Erie, PA (814) 452-2607
"Maxim" Riley-Beard	Shreveport, LA (318) 865-6351	Vapour Phase (Pott Industries)	Walter Kootow Ltd. Agincourt, Ont. (416) 291-9049
	Larger Exhaust Gas Boilers		
Deltak	Minneapolis, MI (612) 544-3371	Foster Wheeler*	St. Catharines, Ont. (416) 688-4434
Dominion Bridge*	Lachine, PQ (514) 634-3551		

AUXILIARIES

	Mufflers		
Granlin (muffler-purifier)	Cummins Ontario Toronto, Ont. (416) 621-9921	Met-Pro (formerly Oxy-Catalyst; muffler-purifier)	Harleysville, PA (215) 723-6751
"Maxim" Riley-Beard	Shreveport, LA (318) 865-6351	Vibron	Mississauga, Ont. (416) 677-4922
		Vibro-Acoustics (BVA Manufacturing)	Toronto, Ont. (416) 291-7371

Manufacturer	Nearest Supplier	Manufacturer	Nearest Supplier
	Radiators		
Sutton Heat Transfer*	Mississauga, Ont. (416) 828-1827	Young Radiator	Kootow Walter Toronto, Ont. (416) 291-9049

APPENDIX C: THIRD PARTY FINANCIAL INSTITUTIONS

Commercial Banks

Project Financing

Canadian Imperial Bank of Commerce
CIBC Project Financing Group
Commerce Court Postal Station
Toronto, Ontario M5L 1A2
(416) 980-5727

Royal Bank of Canada
Corporate Finance and Project Finance Group
Royal Bank Plaza, 200 Bay Street
Toronto, Ontario M5J 2J5
(416) 974-4492

Bank of Nova Scotia
Asst. General Manager Special Projects
Canadian Commercial Credit
44 King Street West
Toronto, Ontario M5H 1H1
(416) 866-6362

Bank of Montreal
Senior Commercial Banking Manager
First Canadian Place, P.O. Box 3
Toronto, Ontario M5X 1A3
(416) 867-5040

Toronto Dominion Bank
Corporate Loan & Banking Division
P.O. Box 1, Toronto Dominion Centre,
Toronto, Ontario M5K 1A2
(416) 982-8186

Assistant General Manager
Commercial Marketing
P.O. Box 1, Toronto Dominion Centre,
Toronto, Ontario M5K 1A2
(416) 982-8186

Project Leasing

CIBC Project Leasing Group
Commerce Court Postal Station
Toronto, Ontario M5L 1A2
(416) 980-5727

Roylease Corporate Finance, Ontario
Royal Bank Corporate Finance Centre
180 Wellington Street West, 10th Floor,
Toronto, Ontario M5J 1J1
(416) 974-7200

President Scotia Leasing Ltd.
181 University Avenue, Suite 420
Toronto, Ontario M5H 2X7
(416) 866-3564

President
Toronto Dominion Leasing
P.O. Box 1, Toronto Dominion Centre,
Toronto, Ontario M5K 1A1
(416) 982-8186

Savings Financing Firms

Rose Technology Group
2235 Sheppard Avenue East
Willowdale, Ontario M2J 5A6
(416) 756-1455

Econoler Inc.
57 Mobile Drive
Toronto, Ontario M4A 1H5
(416) 752-0121

Engineering Interface Ltd.
2 Sheppard Avenue East
Willowdale, Ontario M2N 5Y7
(416) 226-6565

APPENDIX D: UTILITY CONTACTS

Ontario Hydro

All contact with Ontario Hydro should be through the Manager — Marketing in the appropriate Regional Office nearest the proposed location of the cogeneration site:

Central Region	*5760 Yonge Street* *Willowdale, Ontario* *M2M 3T7* *(416) 222-2571*
Eastern Region	*420 Dundas Street East* *Belleville, Ontario* *K8N 5C3* *(613) 966-8622*
Georgian Bay Region	*93 Bell Farm Road* *Barrie, Ontario* *L4M 5C3* *(705) 728-5521*
Northeastern Region	*590 Graham Drive* *North Bay, Ontario* *P1B 8L4* *(705) 472-8000*
Northwestern Region	*34 Cumberland Street North* *Thunder Bay, Ontario* *P7A 4L5* *(807) 343-3411*
Western Region	*1075 Wellington Road* *London, Ontario* *N6E 1M1* *(519) 681-1390*

Natural Gas Utilities

Union Gas franchise area

Contact the Gas Sales Supervisor or Industrial Gas Sales Representative in the local Union Gas office. Additional technical information on cogeneration can be obtained from the Manager of Cogeneration Development, Union Gas, 50 Keil Drive, Chatham, Ontario N7M 5M1 or call (519) 352-3100.

ICG Utilities franchise area

Contact the Area Supervisor — Industrial Sales in the local ICG Utilities office. Additional technical information on cogeneration services can be obtained from the Manager of Technical Services, ICG Utilities (Ontario) Ltd., 245 Yorkland Boulevard, North York, Ontario M2J 1R1 or call (416) 491-1880.

Consumers' Gas franchise area

Contact the Region Sales Supervisor or Utilization Supervisor in the local Consumers' Gas Office. Additional technical information on cogeneration can be obtained from the Manager of Cogeneration Development, Consumers' Gas, P.O. Box 650, Scarborough, Ontarion M1K 5E3 or call (416) 495-5707

APPENDIX E: FOR MORE INFORMATION

Source	Available Information
Ontario Ministry of Energy Inquiries Section 9th Floor, 56 Wellesley Street West Toronto, Ontario M7A 2B7 (416) 965-3246 Long distance toll-free, call operator for Zenith 80420	*Parallel Generation in Ontario* March 1986. Free *Energy Cascading at the University of Ottawa* (pamphlet) Free
Ontario Hydro - contact nearest regional office listed in Appendix D	*Parallel Generation Power Purchase Rates* March 1988. Free *Parallel Generation: Connection Procedure and Requirements* March 1988. Free *Parallel Generation: Purchase and Contract Conditions* March 1988. Free *High Voltage Procedure for Customers and Their Consultants* June 1986. Free
Canadian Electrical Association Research Division Suite 5000 One Westmount Square Montreal, Quebec H3Z 2P9 (514) 937-6181	*Combined Generation of Heat and Electricity* Report 77-60 May 1980. $50* *Utility Policy on Cogeneration and Small Power Production* Report 340 U SOA October 1984. $50* *Utility Policies Towards Customer Owned Generation Facilities* Report 416 U 465 October 1985. $50* *Opportunities for Utility-Owned Packaged Combined Heat and Power Systems* Report 544U 555 December 1987. $50*

* $35 for members

Source	Available Information
Canadian Energy Research Institute 3512—33 Street N.W. Calgary, Alberta T2L 2A6 (403) 282-1231	*Industrial Cogeneration in Canada: Prospects and Perspectives* Study No. 24 March 1987. $30
AEE Energy Books—Dept. 300 **The Association of Energy Engineers** 4025 Pleasantdale Road, Suite 420 Atlanta, Georgia 30340 (404) 925-9558	*Cogeneration and Small Power Manual* 1987. US $85 *Industrial Cogeneration Applications* 1987. US $62
Cogeneration Institute of the Association of Energy Engineers 4025 Pleasantdale Road, Suite 340 Atlanta, Georgia 30340 (404) 447-5083	A non-profit organization representing 1,700 professionals involved in cogeneration. Publishes *The Cogeneration Journal* and sponsors annual workshops and trade conventions on cogeneration.
International Cogeneration Society and International Cogeneration Society Research Institute 309 Commonwealth Building 2045 North 15th Street Arlington, Virginia 22201 (703) 528-5755	Non-profit scientific and educational organization. Publishes *Cogeneration World* (bi-monthly) and *Cogeneration Review* (monthly).
American Gas Association 1515 Wilson Boulevard Arlington, Virginia 22209 (703) 841-8400	*Cogeneration Feasibility Analysis* June 1986 Catalogue No. S00802
Independent Power Producers' Society of Ontario P.O. Box 1084 Station "F" Toronto, Ontario M4Y 2T7 (416) 961-7803	A non-profit organization of independent power producers. Its objectives are to promote a better understanding of independent power production in Ontario, to improve the regulatory and economic environment for independent power production in Ontario, and to assist the growth of a manufacturing industry in Ontario serving an independent power production market.

Source

Energy Technology Data Base
Technical Information Divison
Canada Centre for Mineral and Energy Technology*
555 Booth Street Ottawa, Ontario
K1A 0G1
(613) 995-4059

* for contributing pertinent literature

Canadians can access the ETDB on-line by using a compatible computer through:
- Dialog Information Services (1-800-227-1927)
- Mead Data Central (1-800-227-9597 or (513) 865-6958)
- STN International ((614) 421-3600 or Tlx 6842086CHMAB)

Available Information

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